MOISTURE AND DRYNESS;

OR THE

Analysis of Atmospheric Humidities

IN THE UNITED STATES.

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Analysis of Atmospheric Humidities in the United States.

An Essay read before the American Climatological Association (1884), and Including the Presentation of a Rule of Moisture and Dryness, by which the Climate is Evenly Subdivided, according to the Combined Evidences of Moisture, together with Seasonal Cloudiness and Absolute Humidity Signal Service Charts.

BY

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DRYNESS.

DRYNESS AND ELEVATION THE MOST IMPORTANT ELEMENTS IN THE CLIMATIC TREATMENT OF PHTHISIS.*

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SYNOPSIS: 1. Variability *versus* equability. 2. A rule for classifying climates as to dryness and desirability, based upon low absolute and relative humidities and preponderance of sunshine. 3. The influence of elevation, sunshine, cold, etc., in producing desirable dryness. 4. The physical effect of dryness on man.

THE importance of the discussion of dryness is based upon the proposition: An actually small amount of atmospheric moisture is the most important element in the best climates for phthisis. Any proof of the correctness of this assertion will be deferred until after the consideration of the subject of dryness in its various phases as a climatic attribute. The statement, however, is thus prominently brought to the front because it is decidedly at variance with the past theories and beliefs of the great body of the medical profession. It is, therefore, to our advantage to start squarely and fairly by marshall ing the forces that are thereby brought into controversy, for, as I shall show, the statement puts *variability* over against *equability*, and the latter has heretofore been the darling idea of the medical adviser—the delusive hope of the unfortunate consumptive.

It is to be regretted that the *preponderance-of-opinion* method of settling scientific questions in controversy controls the medical mind of to-day as much as it does. The method is at fault, for it establishes nothing. It simply asserts that a certain number of doctors think one way, and a lesser number, probably governed by much more valuable experience, think differently.

In the winter of 1873–'74 I made an effort to determine some unsettled climatic questions by thoroughly canvassing the experience

* Read before the American Climatological Association, May 3, 1884.

of the medical profession. The result would have been satisfactory were it not for the foregoing criticism. Dr. J. H. Tyndale's late circular, the replies to which were summarized in the "New York Medical Journal," should have resulted in something more trustworthy, because of the later period and the character of the correspondents selected, as having some authority on the question of climate. But the criticism is still in force, and this association has much to do to bring the medical mind "down to bed-rock"—as they say out in the far West—down to something that is sure and settled, something we can pin our faith to and not be disappointed.

I shall endeavor to base the results of this analysis upon facts to be presented, if possible, in a new light, and supported by stated experience, so that your individual judgments will decide that the conclusions are well sustained.

It is to me a pleasing thought that, as scientific searchers after truth, your verdicts as to these conclusions will have no *political* significance, but will be given impartially according to the proofs presented, even though my decisions are contrary—as they will be—to the prevailing beliefs advanced by authors on the practice of medicine.

Instead of the relative humidity alone, I shall prefer the absolute humidity also—i. e., the number of grains of vapor to the cubic foot of air—as the criteria of dryness. The former is only relative at most, and very delusive, if the question of temperature happens to be forgotten. A cool or cold temperature, however, is the chief factor in the production of real dryness or low absolute humidity. It is, then, for me to defend *coldness*, *variability*, and *stimulation* as against their opposites, *warmth*, *equability*, and *enervation*, and to show, as I shall, that variability is the companion of dryness, and equability of moisture.

A definition is here needed as to what is *variability*, or its opposite, *equability*. To be sure, one place may be equable in your judgment, that is more equable than another; but when a climate ceases to be equable and has become variable has not yet been definitely determined. In the absence of anything more definite, I should say the mean of inhabited climates as to changeability should be the line between *variability* and *equability*. I believe this is the only just line we can draw between the two forces placed in opposition. The fairness of this division will better appear as we proceed.

While altitude, wind, and exposure have much to do in determining the variability of a climate, I think I am right in saying the

principal index of this character is the actual humidity. This real humidity is chiefly governed by temperature, for the air can hold invisible vapor in a rapidly increasing amount as temperature changes from cold to hot. From such conditions as solar influence, altitude, latitude, rain, radiation, winds, exposure, etc., the temperature of the air is determined; and these conditions, with temperature as their index, determine the atmospheric humidity. It is almost permissible, then, to say climate is absolute humidity, so much is the latter the key to every attribute of the former. It is in harmony with this close association of temperature with actual humidity, for me to propose the following subdivisions of climate. These I advance on my own authority, and will ask you to accept them, that we may each of us have a clear conception of what the other means in speaking of dryness, equability, etc. I divide climate into four divisions:

1. Excessive dryness, } giving variability.
2. Moderate dryness, }
3. Moderate moisture, } giving equability.
4. Excessive moisture, }

Let us now continue the analysis so as to localize these divisions. The defenders of equability, according to the replies Dr. Tyndale received, in the correspondence already referred to, would combine that quality with dryness, and some of them even with high altitude! My friends, take all the ground you choose, but do not be so generous to your side of the question as to leave us in doubt what you mean by the terms you use. You may have a great deal of *latitude*, but not much *altitude*. I will promise not to douse you under the level of the sea, if you in turn will not force me to the top of Pike's Peak or to the region of the North Pole. We both of us prefer to remain where life can be enjoyed with a moderate degree of comfort. I, however, am willing to include the altitude of ten thousand feet for this latitude in summer, and you may include the torrid zone at sea-level in winter if you choose.

It has given me greater gratification than I can express to you to succeed in producing a classification of climates which I trust will merit your approval, as it is calculated to blot out the inconsistencies which have hitherto run riot in the medical mind. How this classification unfolds will appear as we proceed.

Right here I wish to acknowledge the favor conferred not only upon myself, but upon us all, by the Signal Service Bureau. They have furnished me the following statistics for the stations in the United States, one hundred and thirty-six in number, averaged, as

I requested, by seasons—viz., the mean temperature, mean relative humidity, mean dew-point, mean cloudiness (scale of 0 to 10), mean maximum temperature, mean minimum temperature, mean daily range of temperature, mean monthly extreme ranges of temperature, mean inches of rainfall, mean vapor tension, and mean absolute humidity. I feel that General W. B. Hazen, Chief Signal Officer, and Lieutenant H. H. C. Dunwoody, assistant, deserve much of the credit for the valuable conclusions that are here obtained from these statistics.

Having thus at hand the absolute humidity for the United States, in grains of vapor to the cubic foot of air, I attempted to classify the climates, represented by each of the seasons, for the 45th, 40th, 35th, and 30th parallels of latitude, basing the divisions upon what I know of those climates as belonging to a fair proportionment for excessive dryness, moderate dryness, moderate moisture, and excessive moisture. I was happily surprised by the uniformity of increase in all my subdivisions from the lesser to the greater moisture, and the harmony these divisions seemed to maintain with the changing capacity of the air to contain vapor for equal divisions of temperature. In fact, after many other calculations, I found it took but very slight corrections to make all my subdivisions bear this relation to each other—viz., of the absolute humidity at saturation under 40 per cent. for excessive dryness, 40 to 60 per cent. for moderate dryness, 60 to 80 per cent. for moderate moisture, and above 80 per cent. for excessive moisture. As the absolute humidity depends upon temperature, isotherms were substituted for parallels of latitudes. The faults of these subdivisions were then neutralized by appropriate corrections for relative humidity and cloudiness, and the rule was found to work well for all places.

This first rule was as follows: The relative and absolute humidities and cloudiness in hundredths being known of a given place, find the grains of vapor at saturation either by working it out from the first two or by referring to the first two columns in Glaisher's tables (see Table I), and then take 40, 60, and 80 per cent. of this as the dividing lines between the four divisions of climate. Then correct the absolute humidity for the place to be rated by multiplying it by 100 plus the excess of the relative humidity above the mean 67 per cent., and plus the excess of cloudiness above the mean of 44½ per cent., or by 100 minus these differences if they are below the means.*

* The mean of 67 for relative humidity for the United States I obtained by several methods of computation; for instance, taking places on isothermal lines

Compare this result with the rating numbers already obtained, and the grade of the climate as to dryness is determined.*

Thus every climate is rated forward or backward from the point established by its absolute humidity, according to its excess or deficiency of relative humidity and cloudy weather.

While this rule worked nicely, throwing places of great absolute humidity, high relative humidity, or much cloudiness, proportionately to these excesses, toward the extreme of moisture, and those of opposite preponderance toward the extreme of dryness, according to their deserts, yet there appeared to be objections to it, as stated, which would not obtain with one dependent upon the unchanged records as given by the Signal Service. Besides, the necessity to carry out long computations for each place to be rated, and the possible charge that the rule given was arbitrary, finally led me to change the plan of classification to the following, which is based upon a definite proportion of the rating influence being given to each of the three elements which make up or indicate *dryness*—i. e., relative humidity, absolute humidity, and sunshine, or cloudiness, its opposite, which we have definitely determined by the Signal Service. As nearly as could be done, a third of the rating influence was given to each record indicating dryness or moisture, and the means for these records in the United States were approximately determined to be 67 per cent. for relative humidity, 67 per cent. of saturation at the given temperature of the place for absolute humidity, to be expressed in tenths of a grain of vapor to the cubic foot of air, and 44½ per cent. for cloudiness, zero being no clouds and 100 constant cloudiness. Thus, for rating purposes, I constructed the following table, based upon the means obtained.

to represent the whole country, and also by comparing the fifteen highest with the fifteen lowest relative humidities for all the seasons. The mean of cloudiness was obtained by adding all the means together and dividing by the whole number.

* For instance, Los Angeles, Cal., has an autumn temperature of 64°, relative humidity 65·2, cloudiness 23 per cent., and absolute humidity 4·01 grains to the cubic foot. The capacity of the air to hold moisture at the temperature given is 6·59 grains. The rating divisions then are: Excessive dryness, under 2·64; moderate dryness, 2·64 to 3·95; moderate moisture, 3·95 to 5·27; and excessive moisture, above 5·27 grains. The correction for relative humidity is ·02, and for cloudiness 21 per cent., which gives a rating number 2·83 according to the rule. This moves Los Angeles from moderate moisture back into moderate dryness, its more appropriate position for that season of the year, while Washington, D. C., with an absolute humidity of 3·73 grains, because of both relative humidity and cloudiness being above the mean, is rated forward from moderate moisture into extreme moisture for the same season.

TABLE I.

The Rating Table determinating the Means of Dryness, made up from 67 per cent. of Saturation, in tenths of a grain of vapor for absolute humidity (3), *67 per cent. for Relative Humidity, and 44½ per cent. for Cloudiness, and obtaining* ***One Third of their Sum. See Column*** **(4).**

Temperature, Fahr. (1)	Glaisher's Table. — Weight in grains of vapor in a cubic foot of saturated air. (2)	Sixty-seven per cent. of column (2) in tenths of a grain of vapor. (3)	Rating means of A. H., R. H., and cloudiness combined. (4)	Temperature, Fahr. (1)	Glaisher's Table. — Weight in grains of vapor in a cubic foot of saturated air. (2)	Sixty-seven per cent. of column (2) in tenths of a grain of vapor. (3)	Rating means of A. H., R. H., and cloudiness combined. (4)
Deg.				Deg.			
0	0·545	3·65	38·4	58	5·39	35·98	49·1
2	....	....	38·5	59	...	....	49·5
4	0·649	5·17	38·5	60	5·77	38·66	50·0
6	....	...	38·7	61	...	....	50·4
8	0·772	5·17	38·9	62	6·17	41·34	50·9
10	....	....	39·0	63	...	....	51·3
12	0·916	6·14	39·2	64	6·59	44·15	51·7
14	....	...	39·4	65	...	....	52·3
16	1·090	7·30	39·6	66	7·04	47·17	52·9
18	....	....	39·8	67	...	....	53·4
20	1·298	8·70	40·1	68	7·51	50·32	53·9
22	....	....	40·3	69	...	....	54·6
24	....	....	40·5	70	8·01	53·67	55·3
26	1·674	11·22	40·9	71	...	....	55·7
27	....	....	41·4	72	8·54	57·22	56·2
29	1·892	12·68	41·4	73	...	....	56·8
30	....	....	41·5	74	9·10	60·97	57·5
32	2·13	14·27	41·9	75	...	....	58·1
33	...	....	42·1	76	9·69	64·92	58·8
34	2·30	15·41	42·3	77	...	....	59·5
35	...	....	42·5	78	10·31	69·07	60·2
36	2·48	16·62	42·7	79	....	....	60·6
37	...	....	43·9	80	10·98	73·56	61·2
38	2·66	17·82	43·1	81	...	....	61·9
39	...	....	43·3	82	11·67	78·18	62·7
40	2·86	19·16	43·6	83	....	....	63·5
41	...	...	43·8	84	12·40	83·08	64·3
42	3·08	20·63	44·0	85	....	....	65·1
43	...	....	44·2	86	13·17	88·24	66·0
44	3·32	22·24	44·5	87	....	....	66·9
45	...	....	44·8	88	13·98	93·67	67·9
46	3·56	23·85	45·1	89	...	....	68·8
47	...	...	45·4	90	14·85	99·50	69·8
48	3·82	25·59	45·7	91	....	....	70·8
49	...	....	46·0	92	15·74	105·45	71·8
50	4·10	27·47	46·3	93	....	....	72·8
51	...	...	46·6	94	16·69	111·82	73·9
52	4·32	29·42	47·7	95	....	....	75·0
53	...	....	47·4	96	17·68	118·45	76·1
54	4·71	32·56	47·8	97	....	....	77·3
55	...	....	48·1	98	18·73	125·49	78·5
56	5·04	33·77	48·4	99	....	....	79·7
57	...	....	48·7	100	19·84	132·93	81·0

In the last column (4) in this table we have the mean of relative humidity (67), the mean of cloudiness in hundredths (44½), and the mean of absolute humidity for different temperatures (see column 3) added together, and the sum divided by 3 to obtain the mean of all. By this last—the combined mean as to dryness or moisture—all places can be compared, the average temperature, relative humidity, absolute humidity, and cloudiness of which are known for a given time. The rule is thus simplified to a rating-table for all climates. For instance, Denver, for the autumn of 1883, with an average temperature of 50·4° F., has a rating mean, according to the table, of 46·3; while the record shows relative humidity 50·1 and cloudiness 20 per cent., and absolute humidity, in tenths of grains, 18·9. A third of these three is 29·7. Denver, then, stands to the mean for the United States for that season as 27·7 is to 46·3, or 16·6 on the dry side of the mean. New York city, with temperature 53·9°, has a rating number of 47·8, and with R. H. 69·9, cloudiness 51, and A. H. 32·9, gives a record of 51·3, or 3·5 on the moist side of the rating mean for that same season.

Thus continuing, all the seasons for all the Signal Service Stations in the United States were rated. I then found that twelve, or 12 per cent. on either side of the proper mean, would include nearly all the excesses or deficiencies. Only exceptionally moist or exceptionally dry places would exceed this limit. I therefore gave the first six excess or deficiency to *moderate moisture* and to *moderate dryness*, respectively; and the next six excess or deficiency to *extreme moisture* and to *extreme dryness*, respectively. The finally accepted *climatic rule for dryness* can then be simply stated thus:

With the combined mean of relative humidity and cloudiness per cent., and absolute humidity in tenths of a grain of vapor (see Table I [4]), compare one third of the sum of the actual records given of the same attributes for any place, and the difference, plus or minus, shows the rate of the given climate.

The question may be asked, Are you sure you have not been unjust to damp climates and too generous to very sunny ones in giving nearly one third the rating influence to cloudiness? I think not, most decidedly. The Signal Service estimates all over the country, both of temperature, absolute and relative humidity, are taken *behind the blinds*, and the wonderful influence of the sun, the source of everything that is good in climate, is literally "thrown into the shade" by what we have hitherto trusted as climatic records. This is a most important though a neglected consideration, especially in the clear

TABLE II.

SHOWING COMPARISON OF TWENTY-FIVE DRY WITH TWENTY-FIVE MOIST LOCALITIES, CHOSEN FROM ONE HUNDRED AND THIRTY-SIX SIGNAL-SERVICE STATIONS.

STATIONS.	Mean Temperature. (1) Spring.	Summer.	Autumn.	Winter.	Mean Relative Humidity. (2) Spring.	Summer.	Autumn.	Winter.	Mean Cloudiness in 10ths 0 being no clouds. (3) Spring.	Summer.	Autumn.	Winter.
FIVE DRYEST.												
Fort Yuma, Arizona	69·6	90·1	71·3	55·1	49·1	50·8	42·8	47·0	1·5	2·8	1·8	2·4
El Paso, Texas	62·9	81·5	60·7	45·0	34·2	41·0	53·6	50·4	1·9	2·8	2·0	2·8
La Mesilla, New Mexico	60·8	78·1	59·8	43·4	32·[illegible]	44·4	47·4	49·5	2·6	4·1	2·4	3·7
Pioche, Nevada	44·7	69·0	49·1	30·6	40·2	37·5	42·9	55·4	5·5	3·4	2·4	3·4
Prescott, Arizona	50·6	69·8	52·3	36·8	47·5	48·9	47·1	58·1	1·8	2·7	2·0	2·7
FIVE FIRST HALF EXTREME DRYNESS.												
Santa Fe, New Mexico	46·9	66·4	48·4	30·1	36·1	42·6	44·9	52·1	3·5	4·5	2·3	3·1
Denver, Colorado	47·9	69·1	50·4	28·6	55·8	51·8	50·1	57·4	4·2	3·0	2·0	2·5
Fort Davis, Texas	60·0	74·2	60·4	43·3	44·1	56·6	57·0	51·1	2·9	4·0	2·6	3·4
Red Bluff, California	59·6	81·7	61·2	44·6	59·2	34·4	55·8	69·9	3·2	1·3	3·2	4·1
Fort Grant, Arizona	57·5	50·6	60·0	43·0	38·1	46·3	41·3	55·7	2·5	4·8	2·4	3·2
FIVE SECOND HALF EXTREME DRYNESS.												
Fort Elliott, Texas	54·5	74·0	55·9	31·4	54·7	58·7	63·5	57·4	3·8	4·0	2·7	3·0
Salt Lake, Utah	49·9	74·3	51·5	28·0	46·9	32·9	49·4	56·5	5·0	3·7	4·3	5·3
Cheyenne, Wyoming	40·3	61·8	44·3	33·2	56·6	55·0	47·9	45·8	4·8	3·8	2·7	3·3
Fort Apache, Arizona	50·6	69·6	51·8	35·7	51·4	50·4	53·8	54·8	2·4	1·7	2·5	3·4
Eagle Rock, Idaho	38·2	66·3	39·7	16·7	63·7	39·2	62·3	73·6	4·0	1·4	3·1	4·9
FIVE FIRST HALF MODERATE DRYNESS.												
Fort Assinaboine, Montana	39·8	65·0	39·7	12·1	61·7	50·1	62·9	61·8	5·4	3·2	4·1	4·8
Fort Maginnis, Montana	38·1	61·1	39·4	19·[illegible]	50·9	41·9	5[illegible]·2	54·4	6·2	3·9	5·0	5·8
Fort Concho, Texas	63·5	81·2	64·2	42·8	62·2	59·8	[illegible]	64·[illegible]	4·2	4·5	4·0	4·8
Sacramento, California	58·5	72·4	60·1	45·4	68·9	58·4	68·8	77·8	2·8	0·7	2·4	3·6
Lewiston, Idaho	51·6	72·2	50·0	28·5	62·4	41·9	62·8	76·0	5·1	2·9	5·1	6·5

STATIONS.	Mean Absolute Humidity in grains of vapor to cubic foot of air. (4) Spring.	Summer.	Autumn.	Winter.	Mean Dew-Point. (5) Spring.	Summer.	Autumn.	Winter.	Mean Daily Range of Temperature.* (6) Spring.	Summer.	Autumn.	Winter.	Ratio of each Climate as to Dryness.† (7) Spring.	Summer.	Autumn.	Winter.
FIVE DRYEST.																
Fort Yuma, Arizona	3·68	7·37	3·31	2·21	46·9	67·3	44·2	32·8	30·1	28·9	26·4	22·8	1c+9	1c+7	1c+12	1c+4
El Paso, Texas	1·89	4·30	2·97	1·70	28·9	51·6	40·9	25·4	34·8	32·1	30·2	29·3	1c+15	1c+13	1c+4	1c+1
La Mesilla, New Mexico	1·44	3·88	2·91	1·60	22·3	48·7	40·7	25·5	37·8	33·2	32·3	34·6	1c+14	1c+9	1c+3	1c
Pioche, Nevada	1·21	2·56	1·57	1·06	18·7	37·0	24·5	15·6	23·1	26·4	24·4	19·7	1c+3	1c+12	1c+7	1b
Prescott, Arizona	1·77	3·57	1·97	1·50	27·4	45·8	30·1	23·6	33·7	30·1	31·4	30·8	1c+7	1c+6	1c+6	1b
FIVE FIRST HALF EXTREME DRYNESS.																
Santa Fe, New Mexico	1·19	3·74	1·54	1·10	18·2	40·7	23·9	16·[illegible]	23·9	25·0	23·1	22·3	1c+5	1c	1c+6	1c
Denver, Colorado	1·97	3·08	1·89	1·02	[illegible]·0	46·9	29·3	14·[illegible]	33·4	24·4	24·7	22·0	1a	1c+3	1c+5	1c
Fort Davis, Texas	2·21	4·30	2·95	1·56	33·0	51·5	39·0	24·[illegible]	29·7	25·8	24·8	24·3	1c+6	1c+1	1b	1c
Red Bluff, California	3·12	3·73	3·57	2·24	42·8	47·4	41·9	33·4	23·2	35·2	22·5	17·2	1b	1c+21	1c	2a
Fort Grant, Arizona	1·84	4·15	1·97	1·76	28·7	50·6	34·2	27·[illegible]	26·1	22·5	22·8	20·9	1c+10	2a	1c+10	1b
FIVE SECOND HALF EXTREME DRYNESS.																
Fort Elliott, Texas	2·50	5·28	3·01	1·[illegible]	26·8	57·3	41·5	17·1	25·5	22·7	26·6	25·6	1b	1a	1b	1a
Salt Lake, Utah	1·89	3·01	2·12	1·01	20·0	41·7	31·8	14·1	19·3	22·9	19·0	14·6	1a	1c+12	1b	2b
Cheyenne, Wyoming	1·50	3·08	1·37	1·[illegible]	[illegible]·8	42·2	21·7	[illegible]·9	24·3	29·8	28·1	22·5	2b	1b	1c+3	1c
Fort Apache, Arizona	1·92	3·81	2·21	1·70	29·4	48·0	33·1	26·5	38·1	35·5	37·8	30·8	1c+3	1b	1c+1	2c
Eagle Rock, Idaho	1·63	2·56	1·61	0·81	25·4	37·2	25·0	9·6	23·7	34·5	25·5	20·4	2b	1c+15	1a	2c
FIVE FIRST HALF MODERATE DRYNESS.																
Fort Assinaboine, Montana	1·29	3·23	1·[illegible]	0·59	26·5	43·4	29·6	2·1	24·7	26·0	29·5	20·6	2a	1c+2	2b	2a
Fort Maginnis, Montana	1·29	2·43	1·5[illegible]	[illegible]	[illegible]·9	35·6	23·5	3·7	16·7	21·4	22·4	15·3	2a	1c+3	2b	2a
Fort Concho, Texas	[illegible]	6·[illegible]	[illegible]	2·10	[illegible]·9	61·6	53·4	[illegible]·3	27·9	25·4	23·9	22·8	2c	2b	1a	2a
Sacramento, California	3·74	4·34	2·95	2·01	[illegible]·3	55·7	48·7	[illegible]·5	20·0	28·8	29·7	15·7	2c	1c+4	2c	3a
Lewiston, Idaho	2·56	3·42	2·51	1·34	37·6	45·1	36·5	20·1	21·8	27·2	17·5	12·5	2a	2a	2a	3c

FIVE SECOND HALF MODERATE DRYNESS.																											
Los Angeles, California...	58·7	69·5	61·0	54·1	73·4	72·1	65·2	56·1	3·7	3·3	2·3	2·9	3·87	5·47	4·01	2·66	48·5	58·7	49·6	37·8	23·2	25·1	25·7	21·8	3a	2a	1b	1c
North Platte, Nebraska...	45·8	69·8	47·6	29·5	66·6	69·9	68·7	77·2	5·0	3·3	3·7	3·7	2·29	5·38	1·70	0·97	33·9	57·9	35·4	13·3	23·2	21·7	25·8	26·3	3a	2b	1a	2a
San Diego, California....	58·5	68·1	63·4	54·3	71·6	75·6	69·2	61·9	3·8	2·6	2·6	3·4	3·87	5·66	4·28	2·86	48·7	59·7	51·8	40·1	11·8	11·8	15·6	17·2	3a	2a	2c	1a
Dodge City, Kansas......	51·4	72·8	52·2	26·7	57·4	69·1	66·2	64·8	4·7	3·4	3·4	4·8	2·33	5·85	2·86	1·15	24·3	60·8	39·7	17·0	21·4	25·0	28·5	25·8	2c	2b	2c	2a
Cape Mendocino, Cal.....	48·8	58·9	54·2	46·0	85·2	80·1	78·9	80·1	3·8	0·8	2·5	5·0	3·30	4·45	3·37	1·64	44·1	52·2	44·4	39·5	11·7	11·8	11·7	11·6	3c	2c	2a	2a
FIVE FIRST HALF MODERATE MOISTURE.																											
Lynchburg, Virginia......	55·1	76·4	58·3	38·3	55·6	61·7	67·8	63·8	5·5	5·8	4·5	5·1	2·60	5·95	3·55	1·81	37·7	61·0	46·2	28·3	18·3	17·4	16·2	11·8	2b	3a	3a	3a
Yankton, Dakota.........	43·3	69·8	46·6	14·7	63·3	70·9	70·3	61·8	5·4	4·1	3·1	4·3	2·00	5·66	2·47	0·78	30·9	59·3	36·1	8·5	20·1	22·6	22·1	22·4	3a	3a	2b	2a
Leavenworth, Kansas.....	52·2	73·5	53·5	26·7	59·6	70·5	67·6	72·7	5·8	4·2	4·1	5·5	2·56	6·25	3·08	1·21	36·9	62·6	41·8	18·0	19·0	19·4	19·3	17·5	3a	3a	2a	3c
Savannah, Georgia........	65·8	82·1	68·4	55·0	63·7	71·2	73·6	68·9	4·5	5·1	4·1	5·1	4·38	8·25	5·47	3·61	51·9	71·1	58·4	46·7	16·2	15·3	15·1	16·8	2a	3c	3b	3b
San Francisco, California.	54·1	58·9	57·6	48·8	77·7	80·1	78·8	75·3	3·9	4·3	3·5	3·9	3·68	4·45	4·11	2·91	46·8	52·2	50·4	40·4	11·4	10·2	10·2	8·8	3b	4a	3b	3a
FIVE SECOND HALF MODERATE MOISTURE.																											
Atlanta, Georgia..........	59·3	76·9	63·2	44·4	55·8	67·7	68·7	74·0	5·0	5·7	4·4	6·3	3·61	6·68	4·30	2·65	46·5	64·3	51·3	37·9	18·9	15·4	15·7	15·7	3a	3c	3b	4a
St. Paul, Minnesota.......	40·6	67·3	44·8	9·7	62·7	70·7	68·0	77·5	5·5	5·1	5·6	5·4	1·81	5·11	2·29	0·64	27·9	56·5	31·1	3·9	19·0	20·5	16·6	18·1	3a	3c	3c	4a
Jacksonville, Florida.....	68·1	81·9	71·3	58·8	72·3	74·8	77·4	77·2	4·1	5·1	3·9	4·1	5·10	8·65	6·36	[illegible]	58·3	72·6	63·0	53·2	15·9	14·2	14·1	16·0	3a	4b	3c	3c
Washington, D. C........	50·7	74·7	56·4	23·7	68·3	69·0	74·1	75·5	5·9	5·1	5·1	5·4	2·81	6·25	3·73	1·54	30·5	62·4	47·5	27·6	18·0	18·7	16·1	15·1	3c	3b	3c	3c
Boston, Massachusetts...	43·7	69·3	49·7	28·3	39·4	69·3	74·4	71·7	5·2	4·6	5·6	5·1	2·42	5·38	2·97	1·29	33·5	58·3	41·2	19·9	18·5	20·8	15·2	17·6	3c	3a	4a	3c
FIVE FIRST HALF EXTREME MOISTURE.																											
Milwaukee, Wisconsin....	40·6	65·2	48·0	19·1	68·7	73·1	73·2	76·8	6·1	5·4	5·7	5·9	1·31	4·93	2·81	0·84	30·6	55·7	39·3	14·2	14·4	13·6	11·7	14·9	3c	4a	4a	4b
Atlantic City, N. J........	45·7	70·2	55·5	33·9	78·4	79·6	76·0	74·7	5·5	4·8	5·2	5·2	2·75	6·36	3·73	1·46	38·9	63·2	47·5	27·0	14·0	12·8	11·8	14·7	4b	4b	4a	3c
Nashville, Tennessee.....	57·8	75·6	69·0	40·7	65·9	75·1	75·5	75·5	5·8	5·9	5·3	7·0	3·42	7·13	4·45	2·78	45·2	66·3	52·4	34·9	19·1	18·0	16·9	15·2	3b	4b	4a	4c
Galveston, Texas.........	69·5	83·8	73·7	54·7	74·3	71·7	74·1	81·9	6·0	5·0	4·6	5·8	5·05	8·93	6·68	4·19	61·7	73·4	64·5	49·7	9·3	9·6	8·8	10·7	4b	4a	3c	4c
St. Louis, Missouri......	52·0	73·6	57·3	28·9	81·1	75·0	71·2	81·8	5·6	4·8	4·5	6·2	3·47	6·57	3·68	1·63	45·7	64·2	47·1	25·7	19·0	18·6	17·1	15·4	4c	3c	3b	4c+1
FIVE SECOND HALF EXTREME MOISTURE.																											
Grand Haven, Michigan..	40·8	64·7	48·5	24·1	70·6	77·9	77·2	81·9	5·5	4·6	5·2	7·2	2·04	5·24	3·01	1·29	31·1	57·3	41·3	19·9	12·6	12·3	12·4	10·8	3c	4a	4a	4c+3
Erie, Pennsylvania.......	42·2	58·2	51·6	27·2	69·8	71·7	73·8	78·0	5·6	4·7	5·5	7·8	2·16	5·38	3·19	1·32	32·4	58·2	53·1	22·4	14·0	13·6	13·0	12·6	3c	4b	4a	4c+3
Buffalo, New York.......	38·1	65·6	49·8	23·9	73·7	74·5	73·0	81·5	6·3	5·5	5·3	7·6	1·92	5·10	2·91	1·23	29·6	58·7	40·8	19·3	13·7	12·3	14·0	12·1	4b	4a	3c	4c+4
Indianola, Texas.........	70·5	82·7	73·8	54·1	79·4	77·7	80·3	82·4	5·5	4·2	4·0	5·7	6·46	9·23	7·13	3·95	63·3	74·4	65·8	48·8	11·6	12·7	12·8	12·9	4c	4a	4a	4c
Delaware Breakwater, Del.	47·6	71·5	57·7	35·1	78·3	81·0	80·0	80·6	5·8	5·1	4·6	6·1	2·91	6·79	4·23	2·04	40·7	64·9	51·1	30·7	12·1	12·6	10·7	12·5	4b	4c	4a	4c
FIVE GREATEST MOISTURE.																											
Brownsville, Texas.......	73·7	83·3	75·1	58·1	77·4	76·7	80·2	79·7	6·6	5·1	3·4	6·0	6·90	9·08	6·25	4·43	65·3	74·2	51·1	52·7	14·8	14·5	16·9	16·7	4c+1	4c	3a	4c
Hatteras, North Carolina..	56·1	77·4	64·7	14·9	79·7	80·6	84·1	85·4	5.1	5·3	4·9	5·5	4·07	8·13	5·66	3·07	49·4	70·6	59·4	42·2	12·8	11·4	9·6	12·4	4b	4c	4c	4c
Charleston, S. Carolina...	62·9	81·2	67·6	52·3	76·0	81·3	83·2	80·9	4·5	5·0	4·4	4·8	4·77	9·08	6·15	3·94	51·5	71·8	61·8	48·9	15·3	15·5	13·7	15·0	3a	3a	3a	4b
Fort Macon, N. Carolina..	57·6	77·7	64·5	45·8	80·1	82·2	82·3	82·8	5·0	5·9	5·2	5·6	4·23	8·38	5·47	3·07	51·0	71·5	58·5	42·1	13·9	11·2	12·5	14·2	4b	4c+3	4c	4c
Port Huron, Michigan....	37·4	64·6	47·4	20·9	76·9	77·2	77·9	85·7	6·3	5·8	5·6	7·2	1·97	5·10	2·91	1·13	30·2	56·7	40·3	17·0	15·3	16·0	14·7	13·7	4c	4c	4b	4c+4

* I. e., the difference between the mean maximum and mean minimum temperatures.

† Composed of the mean of relative humidity, cloudiness in hundredths, and absolute humidity in tenths of a grain of vapor to cubic foot, rated according to the rating table. Figures: 1 = Extreme dryness; 2 = moderate dryness; 3 = moderate moisture; 4 = extreme moisture. Letters *a*, *b*, and *c* = thirds of each division reckoned forward or backward from middle division 3. Six hundredths are given to each division, and the plus figures (4 *c*+9, etc.) indicate the excess of certain places.

TABLE III.

SIGNAL-SERVICE STATIONS IN UNITED STATES, RATED IN ORDER OF DRYNESS, ACCORDING TO THE CLIMATIC RULE, FOR WINTER OF 1883 (JANUARY, FEBRUARY, AND DECEMBER), WITH MEAN TEMPERATURE ADDED.

No. in order of dryness.	STATIONS.	Rate.	Tempera-ture, deg.	No. in order of dryness.	STATIONS.	Rate.	Tempera-ture, deg.	No. in order of dryness.	STATIONS.	Rate.	Tempera-ture, deg.
			°				°				°
	OF EXTREME DRYNESS.			44	Des Moines, Iowa.	3b	17·3	90	Wilmington, N. Carolina..	4b	49·3
1	Yuma, Arizona...........	1c+4	55·1	45	Savannah, Georgia........	3b	55·0	91	Moorehead, Minnesota.....	4b	0·2
2	El Paso, Texas..........	1c+1	45·0	46	Fort Bennett, Dakota.....	3b	14·0	92	Kitty Hawk, North Carolina	4b	42·9
3	Denver, Colorado.........	1c	28·6	47	Fort Buford, Dakota......	3b	5·0	93	Mt. Washington, N. H	4b	4·1
4	La Mesilla, New Mexico..	1c	43·4	48	Eagle Rock, Idaho........	3c	16·1	94	Charleston, South Carolina	4b	52·3
5	Cheyenne, Wyoming Ter...	1c	23·2	49	Boston, Massachusetts.....	3c	28·3	95	Cape Henry, Virginia......	4b	40·5
6	Fort Davis, Texas	1c	43·3	50	Atlantic City, New Jersey..	3c	33·0	96	Toledo, Ohio............	4b	26·9
7	Los Angeles, California....	1c	54·1	51	Chicago, Illinois..........	3c	21·8	97	Duluth, Minnesota........	4b	10·2
8	Santa Fé, New Mexico	1c	30·1	52	New Orleans, Louisiana ...	3c	57·9	98	Fort Shaw, Montana	4b	20·6
9	Prescott, Arizona.........	1b	36·8	53	Block Island, Rhode Island.	3c	32·5	99	Memphis, Tennessee.....	4b	42·1
10	Fort Grant, Arizona.......	1b	43·0	54	Deadwood, Dakota........	3c	20·5	100	Smithville, North Carolina.	4b	47·5
11	Pioche, Nevada	1b	30·6	55	New Haven, Connecticut...	3c	26·8	101	Provincetown, Mass.......	4b	30·2
12	Fort Elliott, Texas........	1a	31·4	56	La Crosse, Wisconsin.....	3c	13·9	102	Mobile, Alabama.	4b	53·6
13	San Diego, California.	1a	54·3	57	Jacksonville, Florida......	3c	58·8	103	Atlanta, Georgia	4b	44·4
				58	Keokuk, Iowa.....	3c	22·7	104	Lewiston, Idaho..........	4c	28·5
	OF MODERATE DRYNESS.			59	Philadelphia, Pennsylvania.	3c	34·2	105	Mackinac City, Michigan..	4c	19·2
14	West Las Animas, Col	2c	23·7	60	Palestine, Texas..........	3c	47·3	106	Knoxville, Tennessee......	4c	39·7
15	Bismarck, Dakota	2c	5·8	61	Fort Smith, Arkansas.....	3c	37·8	107	Boisé City, Idaho	4c	31·7
16	Fort Stockton, Texas......	2c	43·5	62	Barnegat, New Jersey.....	3c	33·4	108	Dayton, Washington Ter...	4c	27·5
17	Fort Apache, Arizona.....	2c	35·7	63	Leavenworth, Kansas.....	3c	26·3	109	Cairo, Illinois...	4c	36·2
18	Camp Thomas, Arizona....	2b	43·2	64	Washington, D. C........	3c	33·7	110	Columbus, Ohio....	4c	30·6
19	Visalia, California........	2a	45·2	65	Cedar Keys, Florida.......	3c	60·1	111	Delaware Breakwater, Del.	4c	35·1

20	Fort Maginnis, Montana...	2a	19·6
21	Salt Lake, Utah..........	2a	28·0
22	Cape Mendocino, Cal......	2a	46·0
23	Yankton, Dakota.........	2a	14·5
24	Fort Assinaboine, Montana.	2a	12·1
25	Winnemucca, Nevada.....	2a	27·9
26	Red Bluff, California......	2a	44·6
27	North Platte, Nebraska....	2a	29·3
	OF MODERATE MOISTURE.		
28	Fort Benton, Montana.....	3a	18·3
29	Omaha, Nebraska	3a	19·4
30	Fort Sill, Indian Territory..	3a	39·3
31	Dodge City, Kansas.......	3a	26·7
32	Fort Concho, Texas.......	3a	42·8
33	Dubuque, Iowa...........	3a	17·5
34	Lynchburg, Virginia......	3a	38·4
35	Pike's Peak, Colorado.....	3a	3·1
36	Davenport, Iowa	3a	22·7
37	Sacramento, California....	3a	45·4
38	San Francisco, California..	3a	48·8
39	Portland, Maine.	3b	25·3
40	Huron, Dakota...........	3b	10·8
41	New London, Connecticut..	3b	29·4
42	Fort Custer, Montana	3b	21·4
43	Baltimore, Maryland......	3b	36·0

	OF EXTREME MOISTURE.		
66	Cape May, New Jersey....	4a	37·2
67	Olympia, Washington Ter..	4a	37·3
68	New York City..	4a	30·5
69	Springfield, Illinois	4a	27·0
70	Key West, Florida.... ...	4a	72·3
71	Little Rock, Arkansas.....	4a	43·2
72	Albany, New York...... .	4a	27·7
73	Vicksburg, Mississippi.....	4a	50·1
74	Rio Grande City, Texas....	4a	60·7
75	St. Paul, Minnesota.......	4a	9·7
76	Eastport, Maine	4a	20·2
77	Norfolk, Virginia.........	4a	42·2
78	Montgomery, Alabama.....	4a	51·0
79	Sandy Hook, New Jersey..	4a	31·4
80	Chincoteague, Virginia....	4a	36·7
81	Augusta, Georgia.........	4a	50·3
82	Shreveport, La.....	4a	49·0
83	Milwaukee, Wisconsin.....	4b	19·1
84	Pensacola, Florida........	4b	55·3
85	St. Vincent, Minnesota....	4b	3·5
86	Indianapolis, Indiana..... .	4b	29·0
87	Louisville, Kentucky......	4b	36·9
88	Chattanooga, Tennessee ...	4b	43·2
89	Charlotte, North Carolina..	4b	42·1

112	Fort Macon, North Carolina.	4c	45·8
113	Marquette, Michigan......	4c	17·1
114	Indianola, Texas	4c	54·1
115	Helena, Montana	4c	20·0
116	Detroit, Michigan.........	4c	26·3
117	Hatteras, North Carolina...	4c	44·9
118	Brownsville, Texas	4c	58·1
119	Oswego, New York.	4c	26·5
120	Escanaba, Michigan.......	4c	14·8
121	Galveston, Texas....	4c	54·5
122	Sandusky, Ohio	4c	31·1
123	Nashville, Tennessee......	4c	46·5
124	St. Louis, Missouri..... ..	4c	28·9
125	Pittsburgh, Pennsylvania..	4c	31·7
126	Roseburg, Oregon	4c	39·8
127	Cincinnati, Ohio.........	4c	34·7
128	Cleveland, Ohio.........	4c	25·6
129	Spokane Falls, Wash. Ter..	4c	25·8
130	Portland, Oregon.........	4c	38·8
131	Grand Haven, Michigan...	4c	24·1
132	Alpena, Michigan.........	4c	18·2
133	Erie, Pennsylvania........	4c	27·2
134	Rochester, New York.....	4c	25·8
135	Buffalo, New York	4c	23·9
136	Port Huron, Michigan.....	4c	20·9

air of such climates as are found in the western elevated plateaux, where the powerful effect of sunshine is quickly recorded by the metallic thermometer, and its absence as remarkably noted in the shade (see Diathermancy, farther on). Were it not that sunshine so often goes hand in hand with low humidity records, I should be in favor of giving it more, rather than less, influence in the rating of climates.*

To still further localize each climate with reference to others in the same division, I subdivided each of the larger into three smaller divisions, a, b, c, reckoning forward and backward from the middle line between moisture and dryness.

Thus, having rated over again all the signal stations in the United States, using figures, 1, 2, 3, 4, to designate the four divisions of climate, and the letters a, b, c, the appropriate thirds in each, I had ample source from which to choose proper climates to illustrate the discriminating operation of my rule. To make up the following table (Table II), I chose the dryest five and the moistest five stations, and, besides these, five stations to represent each half of each division of climate, preferring those places which are well-known to climatologists, and which, collectively, besides fairly representing the whole area of the United States, have a somewhat uniform rating for the four seasons of the year.†

Besides the rating of each climate by seasons (see last column),

* The rule takes into consideration temperature, absolute humidity, sunshine, and relative humidity—the four cardinal points in the climatic creed. Of course, altitude, exposure or location, forests, and soil are powerful modifiers to be considered in regard to their effect upon such a rule. We shall see further on how much these influences have already affected the actual humidity, and thus have their appropriate share in the rule. Especially is this the case with elevation, which I intend to show decidedly influences humidity, aside from its effect upon temperature, a fact which, I believe, has never been demonstrated by any one else.

† I ought to here explain that this last consideration of uniformity excluded from the table representative places in the extreme Northwest, as Fort Benton, Fort Custer, and Helena, Montana; Olympia, Washington Territory; Portland and Roseburg, Oregon, which are very generally on the dry side of the mean in summer, and decidedly on the moist side in winter and spring. With this exception, however, the fifty stations given in the table very fairly represent the United States.

The anomalies or extremes brought out by this method of rating are as follows for all the seasons of the United States Signal Stations: The greatest extremes as to dryness were Red Bluff and Visalia, California; Winnemucca, Nevada; and Eagle Rock, Idaho, for summer; El Paso, New Mexico, for spring, because of the almost cloudless seasons at those places. The greatest extremes as to moisture were Spokan Falls, Washington Territory, Port Huron, Mich., and Rochester, N. Y., for winter, because of the high means of all the moisture indicating attributes for the low temperatures of that season.

the table contains all the factors which, with the rating means in Table I (4), are used in giving each climate and season its proper grade as to dryness. The seven columns contain the following means by seasons: Temperature, relative humidity, per cent., absolute humidity in tenths of grains to the cubic foot, dew-point and rainfall in inches, daily range of temperature, monthly extreme ranges of temperature, and rate of each climate expressed in figures 1, 2, 3, 4, and letters a, b, c, as described. (See pages 8 and 9.)

As it is during winter chiefly that the invalid must have a change of climate, the classification for that season, according to the rule, would give a very desirable table. The following table (Table III) is the exact rating for the year 1883, of all the signal-service stations, in order of dryness, the several divisions being separated into groups to indicate their position in the whole scale. Their mean temperatures are added, because temperature, a most important factor, is to have a separate consideration, according to the needs of individual invalids and the esteem in which different physicians hold the arguments in favor of a cool rather than warm temperature. Extremely dry places of widely different temperatures are, however, given, and by the aid of this and the preceding table one may make a choice, with definite reasons for his preference. (See pages 10 and 11.)

While the great majority of signal stations are located in the moister sections of the United States, it is easily seen, by rating all stations for winter, that many are advanced toward the extreme of moisture by the relatively greater dampness due to the lowering temperature of that season. It is in winter that the minimum number of places are found in our first two, or dry, divisions—i. e., 13 in extreme dryness, 14 in moderate dryness, 38 in moderate moisture, and 71 in extreme moisture.*

* Of course, faults in the temperature and humidity statistics will greatly affect the rating result. In fact, the rule may be a means of ferreting out discrepancies, particularly in temperature records. If the temperature of a place is for any reason too high, the humidity records must be relatively too low, because the actual amount of moisture has not changed. I can not but believe that some of the large cities, like Chicago, New Orleans, Baltimore, and Boston (the 51st, 52d, 43d, and 49th, respectively, in the scale for winter), have been unjustly moved back toward dryness by the too high temperatures recorded there, where thousands of tons of coal are consumed each winter. T. C. Mendenhall, of the Ohio State Meteorological Bureau, in "Science" of March 14, 1884, in an article on "A Question of Exposure," called attention to the discrepancies between the State temperature observations and those of the Signal Service, pointing out the influence of exposure, of stone buildings—to which the Signal Service thermometers are attached—and of location, as giving higher records generally, and much less sensitive accounts of

Following out our plan of considering dryness as indicated by the amount of moisture in the atmosphere, let us see how this humidity is influenced by the varying conditions which make up climate—i. e., how dryness is produced. We will consider these conditions in the following order:

Dryness affected by

1. Temperature.
2. Altitude.
3. Latitude.
4. The Seasons.
5. Distance from the ocean, etc.
6. Mountain ranges.
7. Absorbing power of earth.
8. Radiation.
9. Diathermancy.
10. Sunshine.
11. Absolute humidity.
12. Relative humidity.
13. Dryness indicated by variability.

We should then consider the *physical effects of dryness* thus produced, and, if time would allow, draw appropriate conclusions, verified by experience, as to the beneficial effects of dryness in disease. All this is too much for a paper of this character—i. e., to do it thoroughly—so I may be excused if I trust wholly to summarizing the points of evidence except where I have something new to offer.

1. *Temperature.*

Temperature is the greatest of all the producers of dryness. The relative humidity, varying from 30 per cent. or less of saturation up to complete saturation, is of small account compared with the capacity of the air to hold moistures under as widely varying degrees of temperature. A glance at the first wo columns of Table I shows this capacity to be about one half a grain at zero and nearly twenty grains at 100° F. Thus it is seen that a relative humidity of 40 per cent.—an unusual occurrence at sea-level—in a very warm climate really indicates several times more moisture than the atmosphere can hold at saturation—an unusual occurrence in the Rocky Mountains—in a very cold climate.

cold waves than the State observations, which are not usually located in the center of cities. He concludes: "There seems to be little doubt that for temperature measurements it would be well to put stations *near* rather than *in* large cities, and at sufficient distance from them to be free from purely local conditions."

2. Altitude.

It is when the conditions which prevail in the elevated interior of our continent are added to the influence of temperature that the extreme dryness is produced which is characteristic of that section.

Altitude is a very important agent in the production of dryness. The removal of the thick stratum of the, so to speak, vaporized atmosphere, such as covers the sea and lowlands, which intercepts the sun's rays, retains heat, obstructs radiation, and produces equability, is here to be noted. There are many conditions ushered in by altitude which have a favorable drying influence on the atmosphere. Prominent among them all is its cooling influence on temperature. Authorities differ, but it is safe to say there is an average lowering of temperature 3° F. for each ascent of one thousand feet in elevation. These changes are not always uniform for all the strata of the atmosphere, but are nearly so, if we except local and physical conditions which are favorable or detrimental, as the case may be, to certain localities.*

This cooling of the temperature, as we have already mentioned, lessens the capacity of the air to contain moisture, while still other conditions, which elevation insures, lessen the relative amount of moisture the air contains. These conditions are such as the character of the soil, the configuration of the earth's surface, and—what I have not seen noted by others—the expansibility of the air due to the diminution in atmospheric pressure. According to Glaisher's table, a given space of air at a given temperature will hold a given amount of moisture at saturation. If these tables are alike applicable to the atmosphere a mile above sea-level, then there is *relatively*, as well as *actually*, much less moisture in the given space at the elevated station than at sea-level, temperature remaining the same, because some of all the constituents of the air, moisture included, have been driven outside the given space by the expanding influence of lessened atmospheric pressure. Is it not fair, then, to assume that actual dryness is doubly assured by elevation through the cooling process and by the diffusive effect of the expanding air?

3. Latitude.

Latitude insures dryness and variability—or their opposites, moisture and equability—as the distance from the equator is in-

* M. Glaisher, in the records of his balloon ascension, gave the fall in temperature as 5° F. for each of the first four inches of barometric fall; then 4° for each of the next eight, and 4·5° each for the next and last three inches fall.

creased or diminished. This law is varied by the amount and character of the land exposed above the sea, by mountain ranges, and by air and ocean currents. It operates, so far as it goes, like altitude, through the effect of changed temperature, the qualities of moisture and equability following the increased heat toward the tropics, until under the equator greatly elevated localities begin to partake of the equability and moist characteristics of the lowlands in the north temperate zone.

4. The Seasons.

The seasons are, of course, synonymous with temperature in their effect on the humidity of the air. But there is a law to be drawn from the times of the sun's greatest and least influence upon the land and water making up the earth's surface which confines equability to the warm sea-coast, and forbids her association with the desirable dryness that is found in the elevated interior of our continent. Land both absorbs and radiates the sun's heat more than water. The contrasts, then, for both the diurnal and seasonal fluctuations of temperature are exaggerated by land and lessened by the ocean. Land is, then, the *enemy* of equability and a *producer* of variability. Notice Guyot's isothermal lines, for winter and for summer, drawn around the globe (Johnson's "Encyclopædia," p. 981, vol. i). Those seasonal temperature lines which, but for ocean currents, would have run nearly parallel on the broad sea, immediately diverge on striking a continent, the summer isotherms running far to the north, especially in elevated sections, and those of winter bending toward the equator. What better evidence is needed that equability is the companion of the moisture-producing sea, while variability is the necessary consequence of inland elevations?

5. Distance from the Ocean.

Distance from bodies of water and absence of forests are alike favorable to dryness. It is in no small degree due to these characteristics that the extensive plateaux in Wyoming, Colorado, and New Mexico present a uniform dryness of atmosphere not found in the high altitudes of Switzerland (Davos, St. Moritz, etc.), though the latter are in great esteem among foreign physicians. The distilling process constantly going on over the sea and all bodies of water to supply the atmosphere with vapor, which returns to the thirsty land in rain, is wanting in the elevated interior of our continent. Not only is this so, but the more the forests are absent or cleared away, the more the earth is not clothed with thick grasses and undergrowth

(notice the short buffalo-grass, the dry cacti, and the sage-brush of Western elevations), so much the more is the quick draining of the land favored and any approach to the water-distillation of the ocean rendered impossible.

6. Mountain Ranges.

The upward projecting faces of the mountains intercept air-currents which come from a distance over damp, warm valleys, or perhaps an equatorial sea. The atmosphere, charged with 70 to 80 per cent. of invisible vapor, where those currents originated, is quickly raised to saturation by the cooling of the air in its onward, upward, and perhaps northward flight, and, as a result, the moisture is precipitated in rain or snow on the mountain-sides. This process is again repeated on the next interior and higher range of mountains, and again on the next, if there are more, until that occurs which is constantly to be noted in eastern Colorado—i. e., the southwestern winds, having thus traversed many mountain ranges, are the dryest winds that reach that section, while the little rain that falls in the northeastern part of the State is brought by opposite currents from the north Missouri valley. Southward and into New Mexico, however, the same general reasoning holds good, the mountain ranges to the northwest furnishing the dry winds, and the Gulf of Mexico, on the south and southeast, those bringing rain. We find here an explanation of the peculiarity brought out by the rating of places in the extreme northwest section of the United States according to the climatic rule for dryness—i. e., summer very dry, but winter and spring very damp. The low temperature of the cold seasons is like the elevated mountain-sides. The warm equatorial or ocean winds are lowered in temperature and become rain-bearing, or approximately so, as they sweep over that northwestern land.

7. Absorbing Power of the Earth.

The earth has an absorbing power of greater or less degree. The less is seen in saturated and closely packed clay, in the mud of spring-time, and in swampy localities, while, on the other hand, the greater absorption resembles that of thirsty chemicals, such as porous dry sand and light, friable, loose earth. So much does dryness of the air depend upon this absorbing quality of the ground that it is impossible to find a very dry atmosphere where the characteristics of the soil are generally those having the least absorbing power. With this idea in mind, please compare, in the second column of Table II, already given, the fifteen dryest with the fifteen moistest stations. Notice how very

generally the highest relative humidities belong to the places of extreme moisture located in low sections with saturated or clay subsoil, while the lowest relative humidities are very decidedly in places of extreme dryness, all of which are known to be high and representative localities of large areas of dry sand, disintegrated rocks, and gravel, variously mixed. From northern Wyoming, western Nebraska, Kansas, and Texas, west and southwest, even to the Pacific borders of southern California, the latter characteristics abound, promoting the rapid absorption of atmospheric moisture and the quick disappearance of rain and snow.

8. Radiation.

The experience of some of my patients who have resided among the foot-hills and in the cañons along the lower eastern borders of the Rocky Mountains has led to the belief that there was a somewhat increased curative influence there, more than was due to the dryness of the plains. I think we can attribute it to two sources: the greater facility and incentive for the very healthful climbing exercise, and to the increased radiation afforded by the many upturned faces of the broken-up rocks in sections destitute of the grasses and foliage of the level plains. This influence in many valleys, sheltered from strong inclement winds, tends each day during the long cold season to warm and dry the atmosphere in a manner unknown to the open country. It is here to be remarked that, through the effect of increased radiation, heat is necessarily not easily held stationary in the atmosphere, and thus the variability is explained which is remarkable in such exceptionally dry places.

9. Diathermancy of the Air.

The clearness of the air is a potential factor in producing the dryness of a given section. This is the case on the "backbone of the American continent," as the Rocky Mountain region is sometimes termed. There the much better results obtained by invalids occupying rooms on the south than on the north side of a house, the snow rapidly disappearing on the sunny side of a building while water is freezing in the shade, and the intense perception of the heating qualities of the sun's rays when falling on the bare surface of the human body—all these point to a peculiar condition of the stratum of air through which the sun shines.

This diathermancy, or the increased facility with which radiant heat is transmitted, I sought to determine by noting the influence, at various elevations, of the sun's rays upon ordinary metallic ther-

mometers, as compared with the temperatures in the shade.* A sufficient number of observations were taken, excluding, as nearly as possible, the interference of any clouds, winds, or artificial heat, to approximately establish the following as the rule of increasing diathermancy of the air: For each thousand feet rise in elevation there are about four degrees greater difference between the temperatures in the sun and in the shade on perfectly clear days at 2 P. M., as recorded by the black metallic-backed thermometers, other influences than those of shade and sun being excluded.

When applied to sections a mile above the sea, like that east of the Rocky Mountain foot-hills, the estimation of this influence of the clearness of the air is very interesting with reference to increased solar and terrestrial radiation, and, consequently, as already shown, to the dryness of the air. "The solar radiation is rapid, and soon after sunrise the temperature rises because of the slight resistance which the rarefied and dry air offers to the sun's rays, while after sunset the terrestrial radiation is also rapid, because there is no moist envelope shrouding the face of the earth to prevent the natural cooling of the dry ground." †

The therapeutic value of light and sunshine is, unfortunately, too little understood or appreciated. Lombard ‡ states that *light stimulates and darkness impedes respiration*, and, through respiration, of course, animal heat and muscular activity. Moleschott proved this fact by experiments upon himself; and the scientists Bidder and Schmidt, noticing that animals, at rest, produced more carbonic acid

* "The Rocky Mountain Health Resorts." See chapter on the "Diathermancy of the Air," p. 66, second edition, 1882. Boston: Houghton, Mifflin & Co.

† In connection with the diathermancy observations mentioned, I pointed out the criticism to which the Signal Service methods of computing mean temperatures were liable. Particular reference was made to the rapid cooling of the air in the elevated sections named. The Signal Service, to compute their means of temperature, used to combine twice their cold 9 P. M. observations with the almost equally cold 7 A. M. and the one warm 2 P. M. observation, and divide the sum of these by four to obtain the average, a process manifestly misleading when one considers the ten warm hours which in Colorado prevail from 8 A. M. to 6 P. M. It is during these hours that being out of doors in a cold and rarefied atmosphere is especially enjoyable, and they are in strong contrast to those hours which used to make up three fourths of the day in the estimation of the Signal Service Bureau. The present method, however, according to which the foregoing data were obtained, is much nearer just to all sections. It consists in combining the 7 A. M., 3 and 11 P. M. observations, and dividing by three to obtain the daily records.

‡ "Traité de climatologie médicale," par le Dr. H. G. Lombard, de Genève, Paris, 1877, p. 221, t. i.

in the day-time than at night, equalized the amount by depriving them of the influence of light. The experience of consumptives, some sixteen in all, seeking reputed benefit from the *equable* temperature of the Mammoth Cave in Kentucky, resulted, of course, in failure, five dying within a short time and others being injured—a result due, undoubtedly, to the darkness and dampness combined.

10. Sunshine.

It is no wonder that the sun has been the deity of worshiping millions, where his Creator has been unrecognized, for the source of life and means of growth of every living thing is the orb that ushers in the light and warmth of day. Almost equal to the combined evidence of both absolute and relative humidity—as to the dryness and desirability of a given climate—would be an exact statement of the proportionate time the sun shines over the country. Of course, the open and elevated sections would have proportionately more sunshine than towns secluded in valleys, and this would be in addition to that due to the more cloudless skies of the elevated interior.

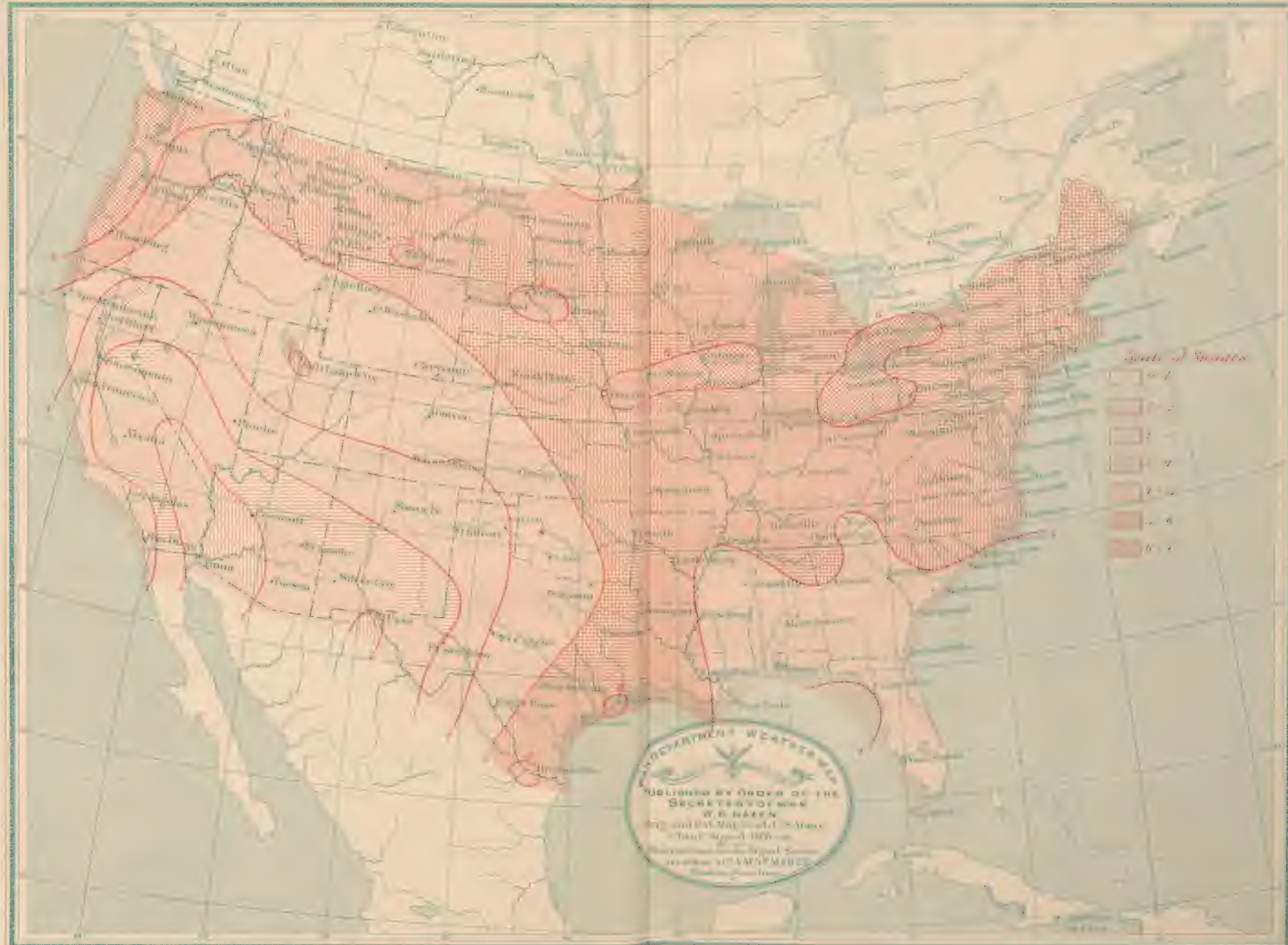
No such records for the United States have been taken, however, and the nearest approximation to accuracy now obtainable are the cloudiness observations as made by the Signal Service and reported by telegraph at 7 A. M., 3 P. M., and 11 P. M., Washington time. These observations, averaged for seasons and graphically illustrated to represent the whole United States, I have been desirous of obtaining for several years past. I am pleased to be able to present them now as compiled by the Signal Service officers.*

The four charts shown represent the mean cloudiness in tenths, zero being no clouds, and ten entire cloudiness.

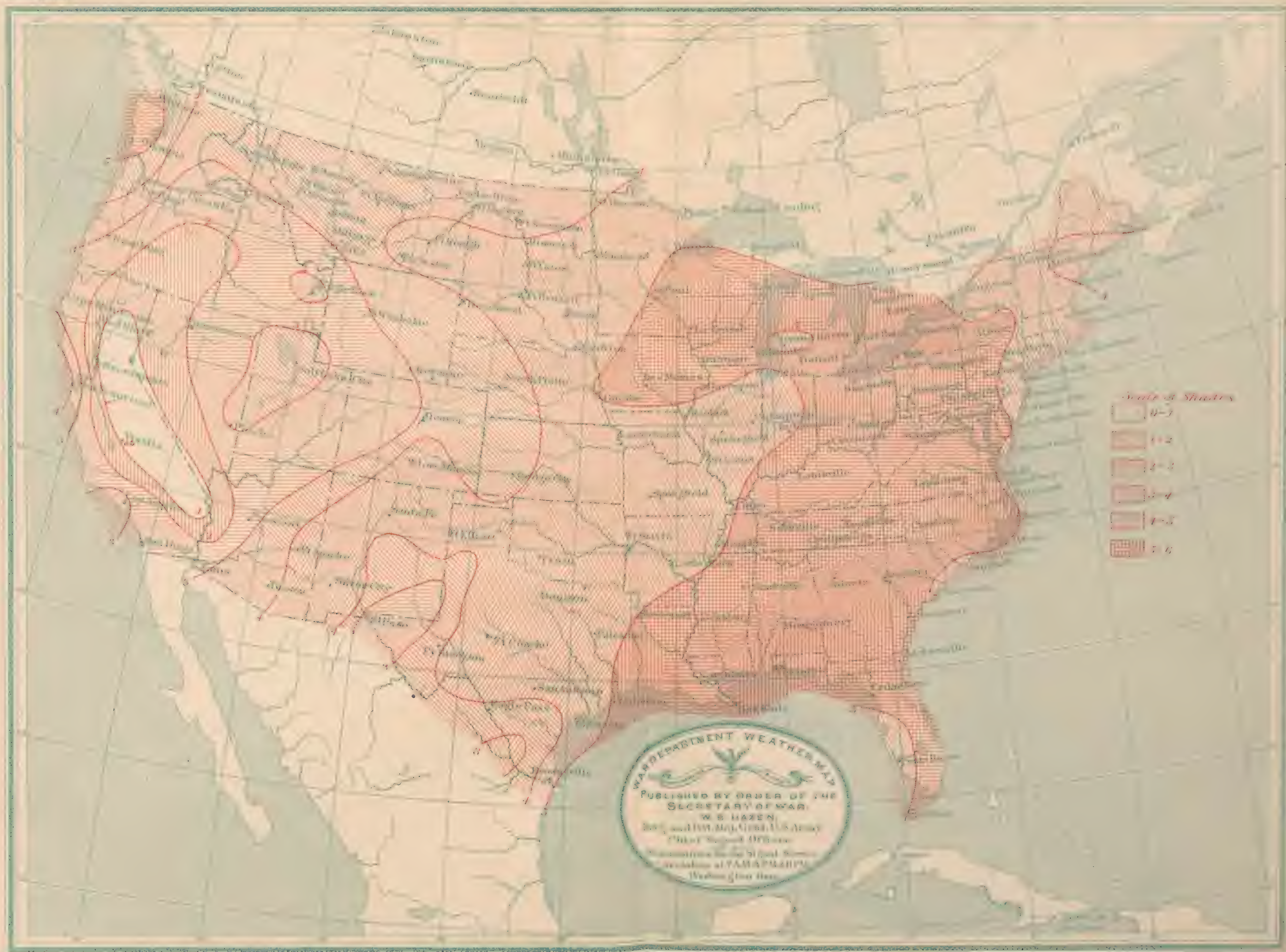
Chart I, for spring, shows the upper section of the United States, from Washington Territory to Maine, and again from Maine along the Atlantic coast to North Carolina, also from Michigan south to Texas—a large section, where over five tenths of the observations showed cloudiness, while South Carolina, Georgia, Florida, and the entire southwest, from Wyoming to western Texas and southern California, are below five tenths cloudy; much of this region is far

* These charts, both for cloudiness (I, II, III, IV) and absolute humidity (V, VI, VII, VIII), were prepared by the Signal Service Bureau in response to a request presented by the author to the Colorado State Medical Society at the session of 1883. A similar resolution, passed by the section on Practice of Medicine of the American Medical Association four years ago, resulted in nothing, for lack of the necessary interest on the part of the publishing committee.

Mean Cloudiness, in tenths. Spring, 1882.

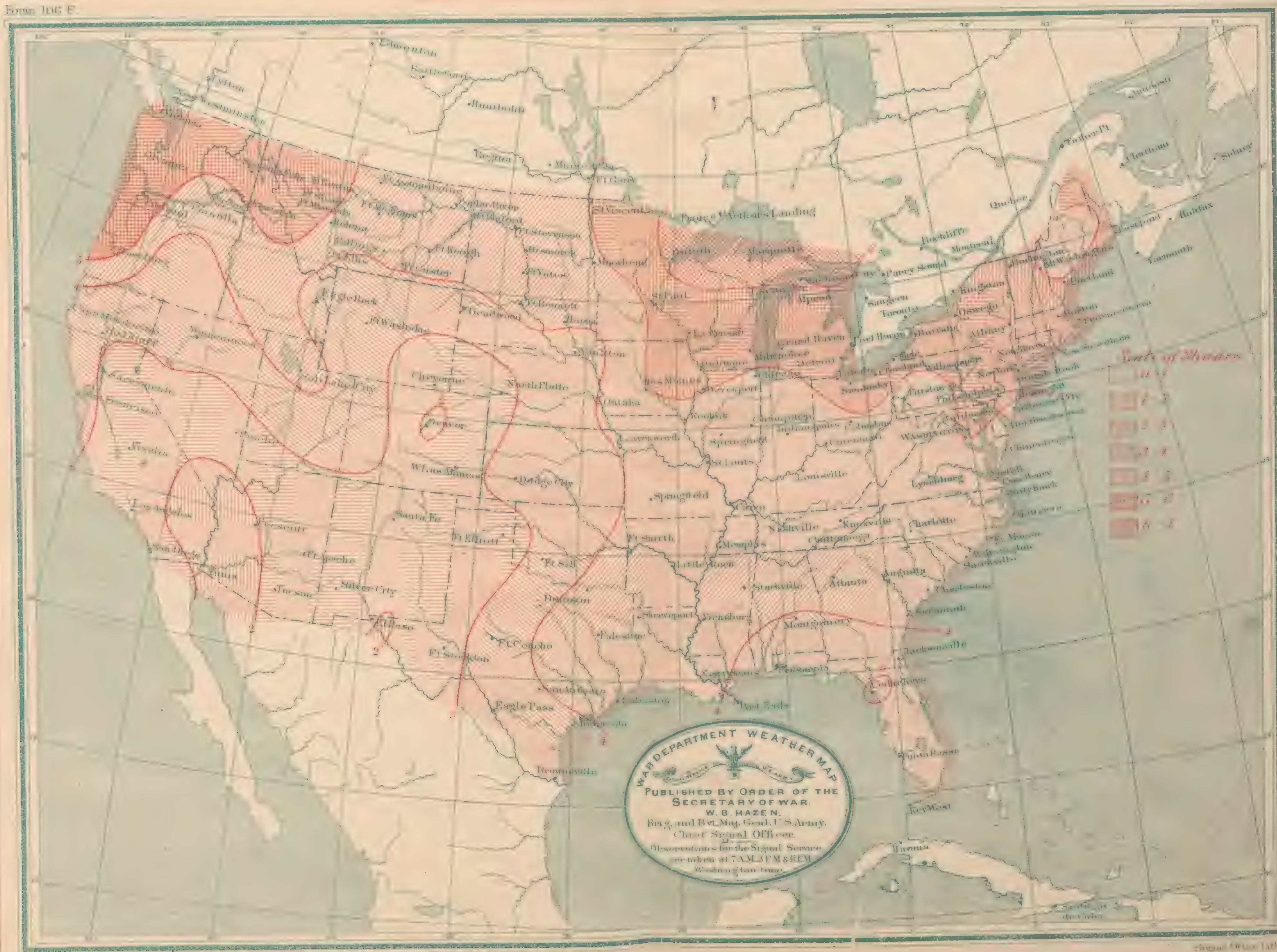


Mean Cloudiness, in tenths. Summer, 1882.

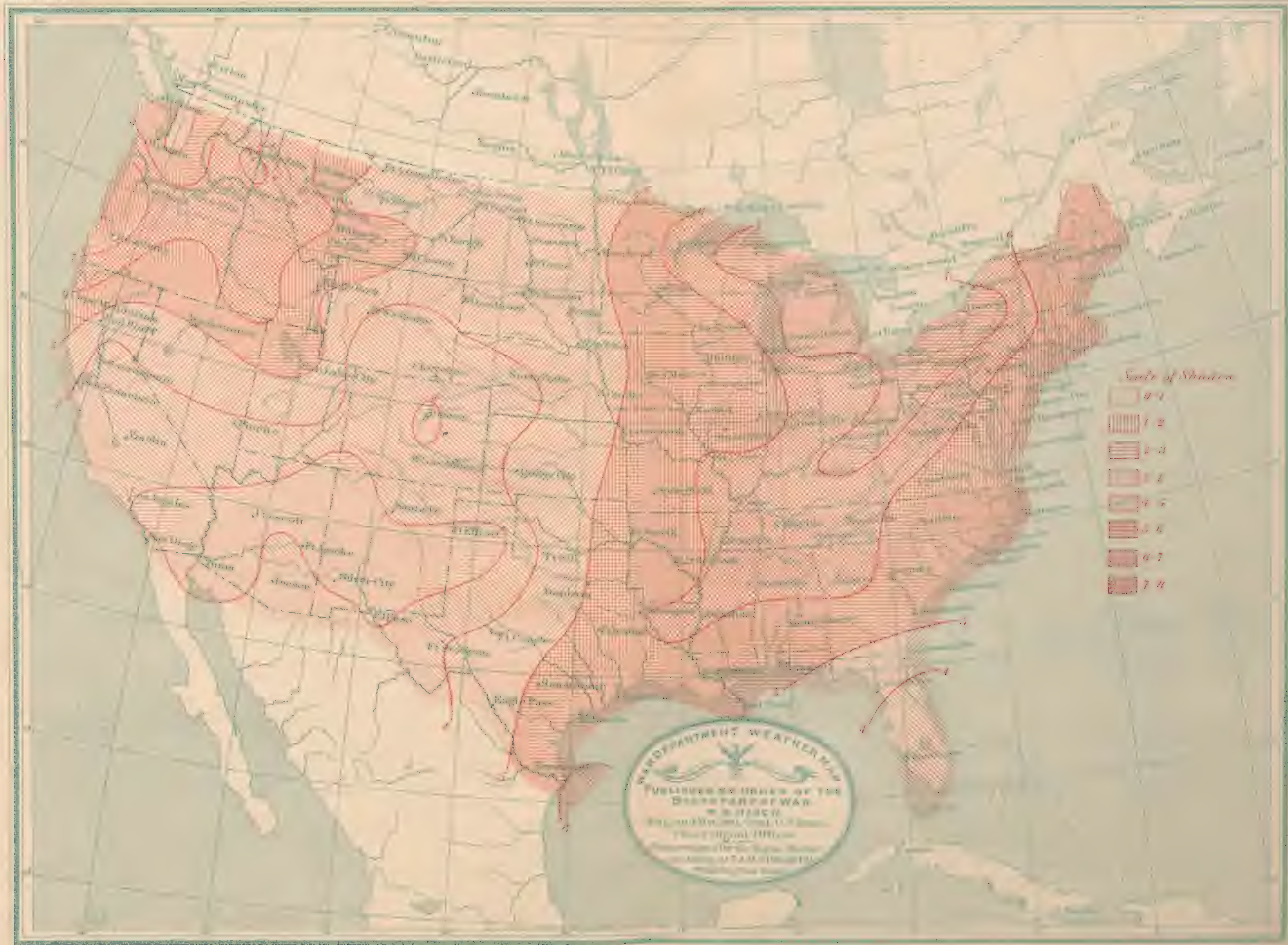


Mean Cloudiness, in tenths. Autumn, 1882.

Form 106 F.



Mean Cloudiness, in tenths. Winter, 1882.



below that, the sections represented by Yuma and El Paso being less than two tenths.

Chart II, for summer, shows the much more equal distribution of clouds over the country than for any other season. In general, the eastern third of the United States, excepting the New England States and the Atlantic coast above North Carolina, are above five tenths, and nearly the whole of the western two thirds of the country below that. The eastern portion of California (Sacramento, Visalia, and the Death Valley) is even less than one tenth cloudy.

Chart III, for autumn, is, like spring, a fairer representation of the cloudiness for the whole year than either winter or summer, and yet there is a slight shifting of the most cloudy sections. Here the region of the lakes, the north Atlantic coast, and the northwest corner of the United States bear off the palm for cloudiness, being over five tenths; while the southwest is remarkable for the absence of clouds —Denver, El Paso, and Yuma being below 20 per cent. cloudy.

Chart IV, for winter, is characterized by the marked preponderance of cloudiness in two directions—the Mississippi and Ohio Valleys—where the percentage is above six, and the lake region, where it is above seven tenths, while in Washington Territory and Oregon the average is above six tenths cloudy. This is in perfect accord with the rating of all stations by the rule, as before explained. Central Colorado (Denver) and much of New Mexico, Arizona, and southern California show the least cloudiness—namely, two to three tenths.

11. *Absolute Humidity.*

A small number of grains of moisture to the cubic foot of air for a given temperature is the most exact measure of the dryness of a given locality that we can obtain from any one attribute of the atmosphere. If isotherms were run—as they should be—through the four accompanying charts, which give for seasons the grains of vapor to the cubic foot of air all over the United States, the variation of each locality from saturation could easily be determined by the aid of the preceding table of Guyot (Table I, column 2). The actual and relative dryness would thus be apparent for each separate place investigated. However, these charts (Charts V, VI, VII, VIII) show, in striking contrast, the much greater amounts, by accurate measurements, of moisture that the atmosphere contains in some portion of the United States than in others. For instance, for spring, summer, and autumn (Charts V, VI, VII), much of Wyoming, Colorado, New Mexico, Arizona, and Nevada contain one fourth in spring, one third

in summer, and about one fifth in autumn, as much atmospheric vapor as Florida and the gulf coast in Texas, while in winter the greatly lessened capacity of the air to hold moisture at low temperatures is exemplified in the frozen atmosphere of the northern interior section, where there is not one tenth the absolute humidity there is on the gulf coast.

12. Relative Humidity.

TABLE IV.

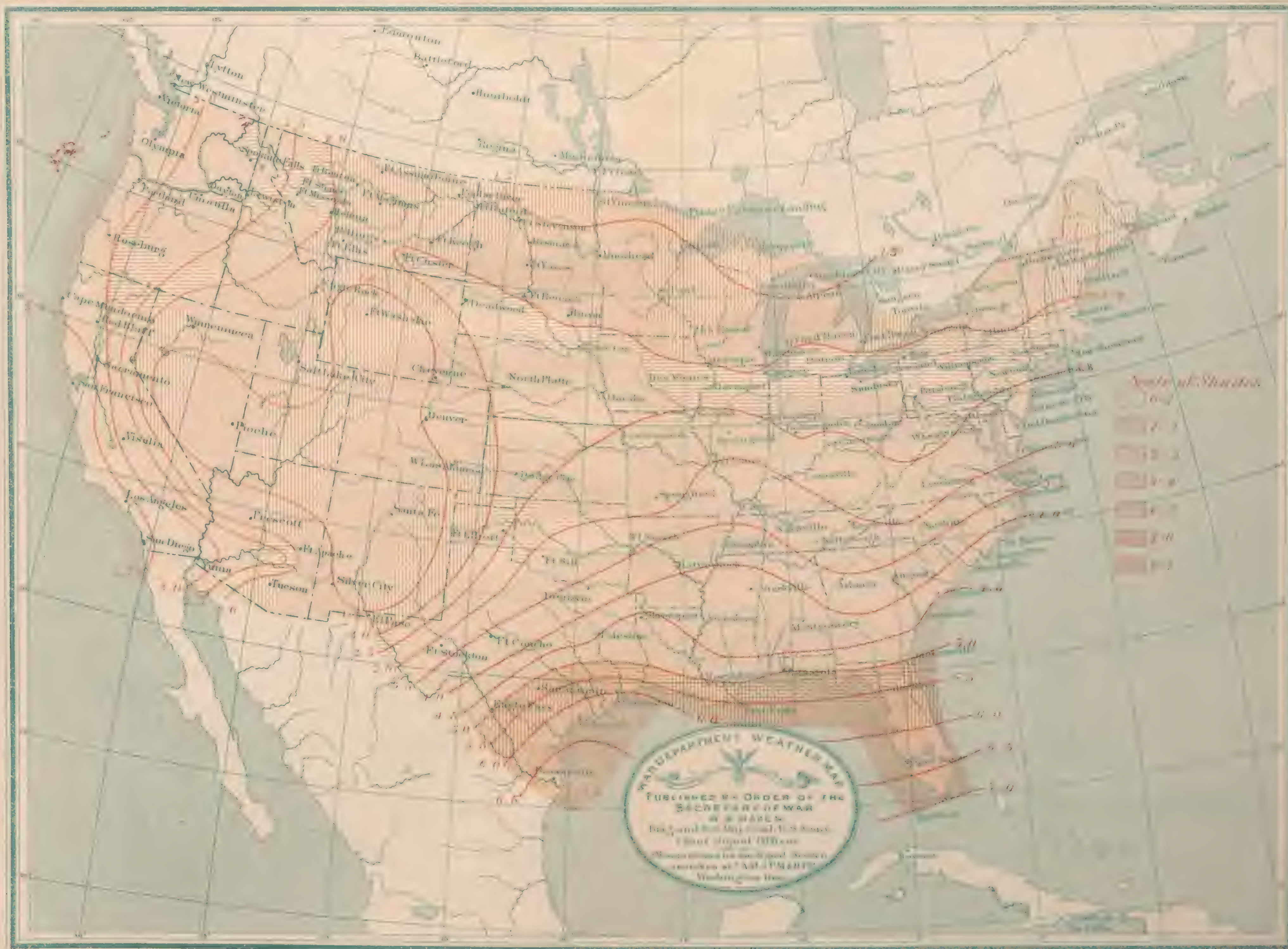
Places of Greatest and Least Relative Humidities, by Season and the Year 1883.

	Spring.	Summer.	Autumn.	Winter.	Average.
GREATEST.					
Mt. Washington, New Hampshire	91·9	91·5	88·6	86·5	89·6
Hatteras, North Carolina	79·7	80·6	84·1	85·4	82·6
Fort Macon, North Carolina	80·1	82·2	82·3	82·8	82·1
Cape Mendocino, California	85·2	80·1	78·9	80·1	81·1
Charleston, South Carolina	76·0	80·3	83·2	80·9	80·1
Pike's Peak, Colorado	83·9	75·5	78·7	81·3	80·0
Chincoteague, Virginia	76·8	81·8	80·1	78·8	79·6
Delaware Breakwater, Delaware	78·3	81·0	80·0	80·6	78·5
Smithville, North Carolina	77·8	77·3	79·2	82·5	78·5
San Francisco, California	77·7	80·1	78·8	75·3	78·3
St. Louis, Missouri	81·1	75·0	71·2	84·8	78·0
Kitty Hawk, North Carolina	77·7	77·9	77·9	78·6	78·0
Philadelphia, Pennsylvania	75·5	83·2	79·0	71·5	77·6
Deadwood, Dakota	83·6	71·7	72·9	81·1	77·6
Atlantic City, New Jersey	78·4	79·6	76·0	74·7	77·2
Average	80·2	79·8	79·4	80·3	79·9
LEAST.					
La Mesilla, New Mexico	32·0	44·4	47·4	49·5	43·2
Fort Grant, Arizona	38·1	46·3	41·3	55·7	43·3
Santa Fé, New Mexico	36·1	42·6	44·9	52·1	43·9
Pioche, Nevada	40·2	37·5	42·9	55·5	44·0
El Paso, Texas	34·2	41·0	53·6	50·4	44·8
Salt Lake, Utah	46·9	32·9	49·4	56·5	46·4
Yuma, Arizona	49·1	50·8	42·8	47·0	47·4
Cheyenne, Wyoming	56·6	55·0	47·9	47·8	49·3
Winnemucca, Nevada	52·0	28·6	52·9	65·5	50·0
Prescott, Arizona	47·5	48·9	47·1	58·1	50·4
Fort Davis, Texas	44·1	50·6	57·0	51·1	50·7
Fort Maginnis, Texas	50·9	41·9	56·2	51·4	51·6
West Las Animas, Colorado	46·3	48·9	53·4	61·0	52·4
Camp Thomas, Arizona	47·4	42·5	44·5	69·6	53·5
Denver, Colorado	55·8	50·8	50·1	57·4	53·8
Average	45·2	42·8	48·8	55·2	48·3

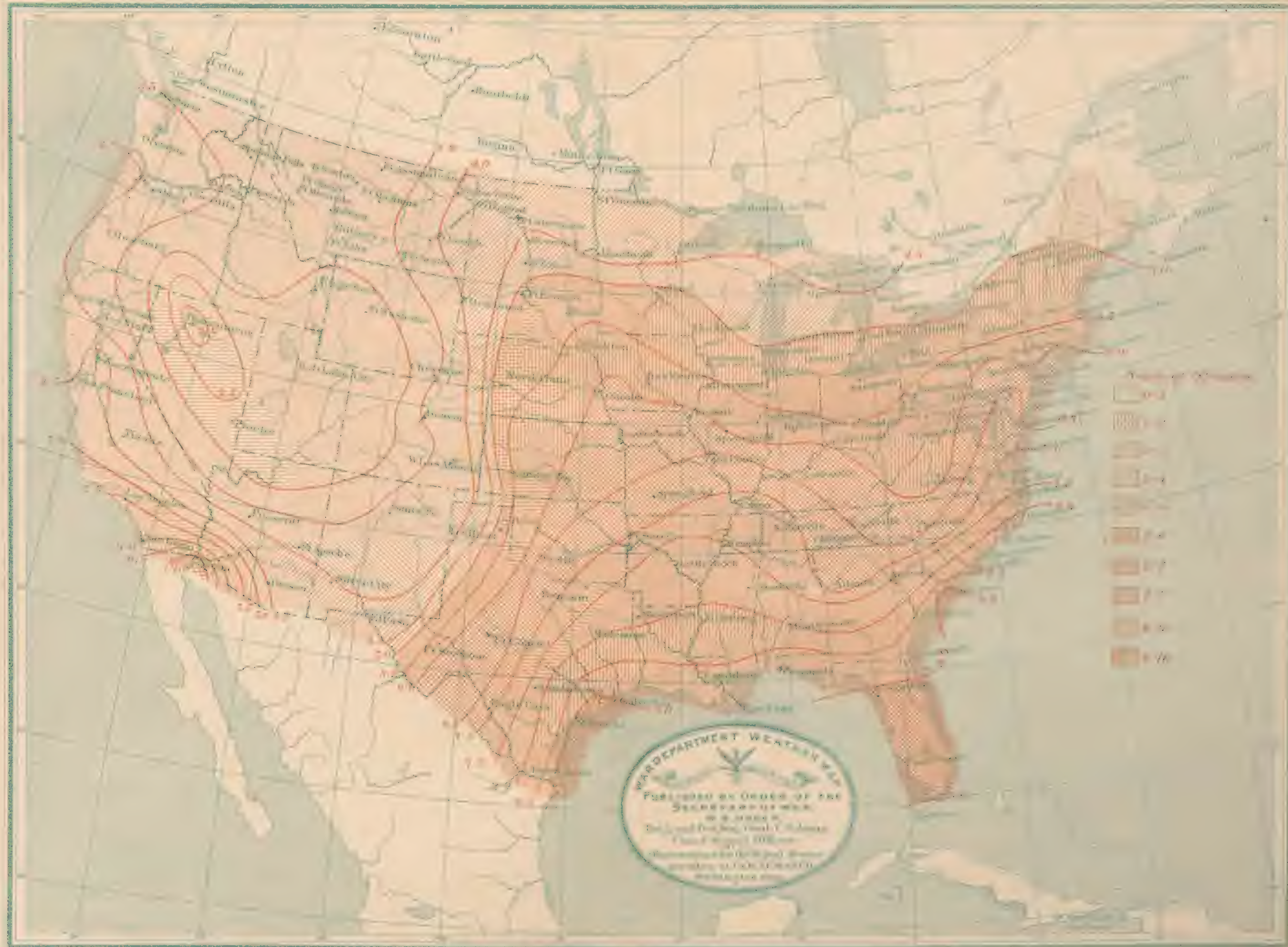
There are but a few exceptions to the statement that the combined forces which produce atmospheric dryness also give a low rate of rela

Form 106 F

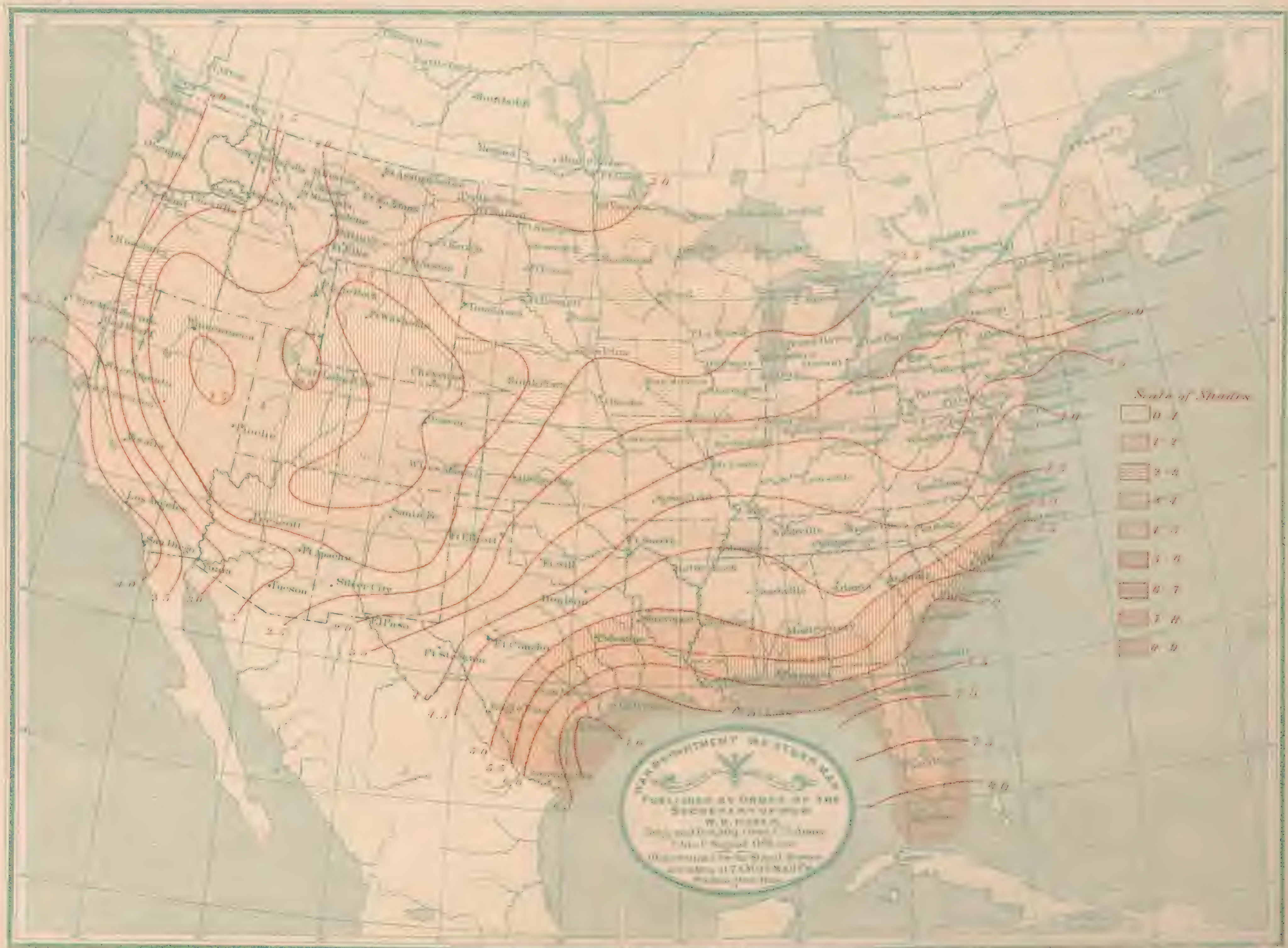
Spring (absolute Humidity) weight of aqueous vapor, in grains, contained in each cubic foot of air.



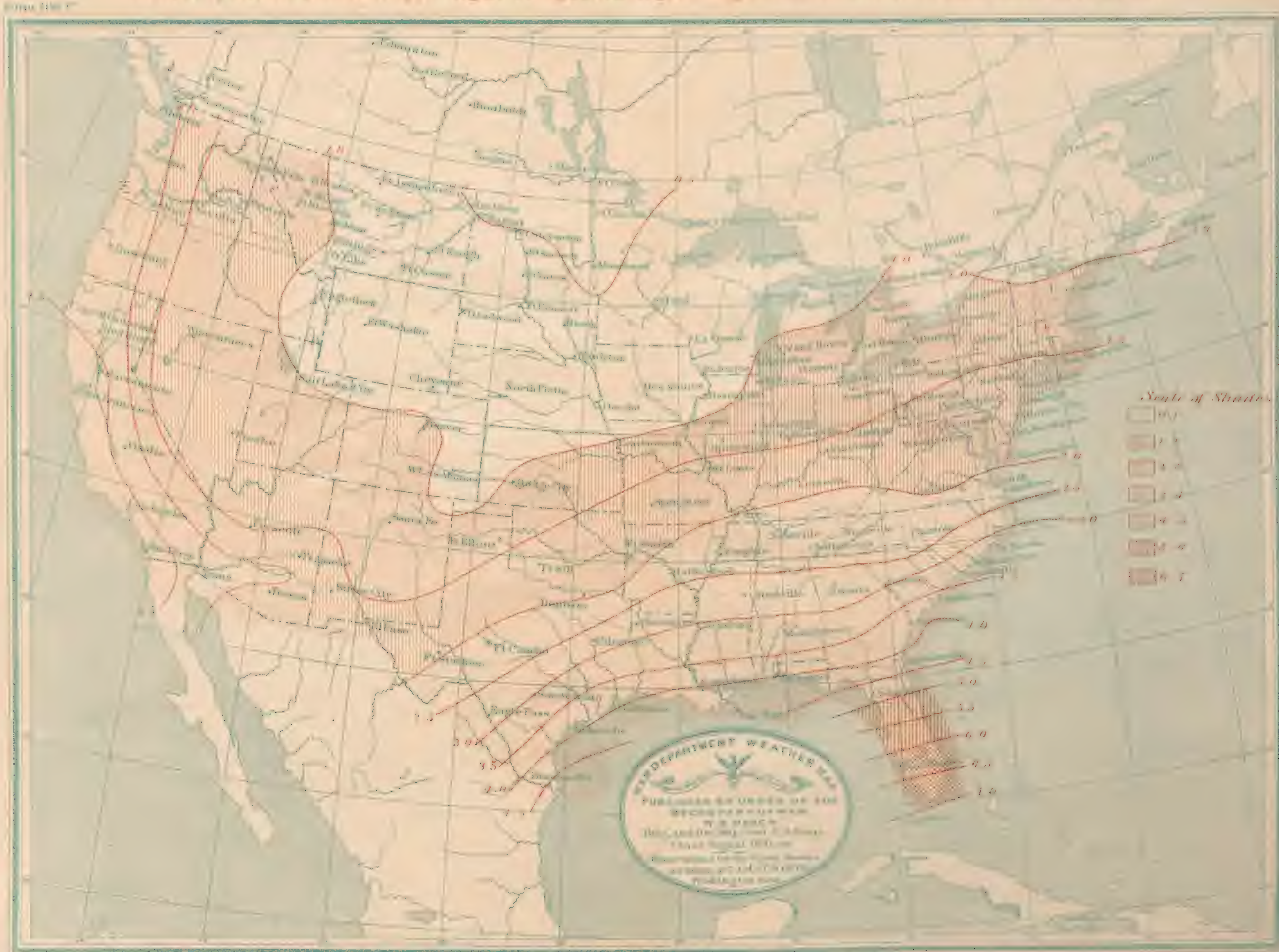
Summer (absolute Humidity) weight of aqueous vapor, in grains, contained in each cubic foot of air.



Autumn (absolute Humidity) weight of aqueous vapor, in grains, contained in each cubic foot of air.



Winter (absolute Humidity) weight of aqueous vapor, in grains, contained in each cubic foot of air.



tive humidity. Saturation of the air with invisible vapor being 100 per cent., the relative per cent. actually found in the air is usually in harmony with the condition of dryness or moisture of a locality, 67 per cent. of saturation being about the mean for the United States.

But the few exceptions that there are to the above statement are sufficient to render relative humidity alone an unsafe guide as to the question of dryness. I think I have given this factor its full proportion of rating power in the rule for dryness by combining it—with its usually higher percentages—with both cloudiness and absolute humidity.

Relative humidity is somewhat fickle, because it is greatly influenced by purely local causes. For instance, currents of air which are absolutely dry, when rising to a higher and inland point, become relatively moist and different from the undisturbed atmosphere of the locality or its immediate neighborhood. The high relative humidities of Mount Washington, Pike's Peak, and partly so of Deadwood, Dakota, Cape Mendocino, and San Francisco, Cal., in the foregoing table (Table IV), which gives the fifteen greatest and fifteen least mean relative humidities in the United States, are thus explained.

13. Dryness Indicated by Variability.

Hitherto it has not been customary for climatologists to see any good in variability.* They have rather preferred to champion its opposite—equability. It does not seem to have occurred to them that the qualities which they praised, such as clearness and purity of atmosphere—especially its freedom, with increasing elevation, from disease germs and the evidences of the lower forms of life which thrive on warmth, moisture, and equability—are largely due to the great seasonal and other ranges of temperature and to the nightly chilling or perhaps freezing of the atmosphere. It is not necessary to introduce any argument of a speculative character. Statistics prove, beyond the possibility of successful contradiction, that variability is a distinguishing attribute of really dry places—whether elevated above sea-level or not—and that equability is, as a rule, characteristic of a uniformly damp atmosphere.

* If it is attempted to make any exception in favor of such places as Cape Mendocino or other California towns bordering on the ocean, let it be understood that, though the ground is dry and parched, the equability is due to a continuous moist wind which blows landward from the Pacific Ocean and does not part with its equable characteristics until, rising on the interior ranges of mountains, it has lost its moisture and become dry and therefore variable.

The following table, giving fifteen places each of the greatest and least mean daily ranges of temperature for seasons and the year from all the Signal Service stations in the United States, is a sufficient proof in itself of the general statement here made. So also is the

TABLE V.

Places of Greatest and Least Mean Daily Ranges of Temperature (1883).

	Spring.	Summer.	Autumn.	Winter.	Average.
GREATEST.					
Fort Apache, Arizona	38·1	35·5	37·8	30·8	35·5
La Mesilla, New Mexico	37·8	33·2	32·0	34·6	34·4
Prescott, Arizona	33·7	30·1	31·4	30·8	31·5
West Las Animas, Colorado	30·0	29·2	33·4	35·8	31·3
El Paso, Texas	34·8	32·1	30·2	26·3	30·8
Camp Thomas, Arizona	33·9	29·0	32·1	28·5	30·8
Fort Stockton, Texas	32·7	26·7	26·4	27·7	28·3
Winnemucca, Nevada	26·0	35·3	28·1	22·5	27·9
Yuma, Arizona	31·0	28·9	26·4	23·8	27·3
Visalia, California	26·1	33·6	29·2	18·1	26·7
Fort Davis, Texas	29·7	23·8	24·8	24·3	25·6
Fort Elliott, Texas	25·5	22·7	26·6	25·6	25·1
Fort Concho, Texas	27·9	25·4	23·9	22·8	25·0
Fort Benton, Montana	24·9	27·9	21·4	25·2	24·8
Denver, Colorado	23·4	24·4	24·7	22·0	23·6
Average	30·7	29·1	28·4	26·5	28·7
LEAST.					
Eastport, Maine	13·0	18·3	10·8	15·4	14·3
Provincetown, Massachusetts	12·6	18·3	9·8	12·1	13·2
Buffalo, New York	13·7	12·5	14·0	12·1	13·0
Sandusky, Ohio	13·7	13·0	11·8	12·4	12·7
Indianola, Texas	11·6	12·7	12·8	12·9	12·5
Cedar Keys, Florida	13·2	11·2	13·1	12·5	12·5
Barnegat, New Jersey	12·4	13·3	10·6	13·4	12·4
Sandy Hook, New Jersey	13·8	13·8	10·2	12·1	12·4
Delaware Breakwater, Delaware	12·1	12·6	10·7	12·5	11·9
Cape Mendocino, California	11·7	11·8	11·7	11·6	11·7
Hatteras, North Carolina	12·8	11·4	9·6	12·4	11·5
Block Island, Rhode Island	10·0	11·6	9·0	12·2	10·7
San Francisco, California	11·4	10·2	10·2	8·8	10·1
Key West, Florida	10·2	12·5	8·4	8·8	9·9
Galveston, Texas	9·3	9·6	8·8	10·7	9·6
Average	12·1	12·9	10·8	12·0	11·9

record of the mean daily and mean monthly ranges of the twenty-five dry and the twenty-five moist localities (for the former see Table II, and for the latter see Table VI, giving monthly ranges with average precipitation added), and chosen without any reference to this particular evidence. For the four divisions of climate the total mean daily and monthly ranges, averaged for the year, are as follows:

	Means of Daily Ranges.	Means of Monthly Ranges.
1. Extreme dryness	36·51° F.	53·65°
2. Moderate dryness	20·63°	49·38°
3. Moderate moisture	17·09°	45·48°
4. Extreme moisture	13·61°	41·55°

TABLE VI.

	Average precipitation. Inches of rain and melted snow, computed from commencement of observations to January 1, 1884. (5)				*Means of extreme monthly ranges of temperature, from commencement of observations to January* 1, 1884. (8)			
	Spring.	Summer.	Autumn.	Winter.	Spring.	Summer.	Autumn.	Winter.
FIVE DRYEST.								
Yuma, Arizona	0·18	0·48	0·16	1·26	50·5	45·2	48·4	43·2
El Paso, Texas	1·09	6·17	2·52	1·72	57·5	43·9	52·1	52·9
La Mesilla, New Mexico	1·21	2·81	2·14	1·74	60·4	49·4	59·2	60·1
Pioche, Nevada	1·86	1·76	0·98	1·87	53·3	47·0	52·9	48·7
Prescott, Arizona	2·18	5·86	2·32	3·38	61·1	52·8	57·1	60·8
FIVE FIRST HALF EXTREME DRYNESS.								
Santa Fé, New Mexico	1·93	7·56	3·18	1·81	54·4	43·3	50·2	52·1
Denver, Colorado	5·62	5·03	2·47	1·69	62·1	49·7	62·7	68·0
Fort Davis, Texas	2·30	11·99	4·35	1·18	55·7	45·3	50·7	63·4
Red Bluff, California	7·08	0·21	4·44	17·12	49·3	50·0	45·6	37·4
Fort Grant, Arizona	1·59	8·63	2·62	2·69	52·2	40·1	46·4	49·1
FIVE SECOND HALF EXTREME DRYNESS.								
Fort Elliott, Texas	6·41	8·01	6·03	0·84	62·5	49·0	62·3	72·0
Salt Lake, Utah	6·42	2·18	4·26	4·12	47·2	47·4	49·2	41·3
Cheyenne, Wyoming	3·65	4·63	1·90	0·50	60·8	52·4	62·6	65·3
Fort Apache, Arizona	2·36	10·78	4·67	4·49	60·7	54·4	57·4	62·9
Eagle Rock, Idaho	4·74	2·07	3·39	8·48	51·8	59·3	61·5	61·0
FIVE FIRST HALF MODERATE DRYNESS.								
Fort Assinaboine, Montana	2·92	4·44	3·19	3·22	59·5	52·3	59·9	74·9
Fort Maginnis, Montana	3·58	1·71	3·88	2·92	52·7	54·3	59·3	79·3
Fort Concho, Texas	6·00	10·51	8·33	3·62	57·7	44·1	54·4	61·3
Sacramento, California	7·69	0·12	2·53	11·37	41·9	45·6	43·0	33·0
Lewiston, Idaho	3·56	2·06	4·11	8·07	50·4	52·4	45·5	43·8
FIVE SECOND HALF MODERATE DRYNESS.								
Los Angeles, California	4·28	0·02	1·57	8·86	46·0	39·0	46·9	41·7
North Platte, Nebraska	5·47	9·32	3·29	1·79	64·5	51·3	65·4	68·6
San Diego, California	1·91	0·30	1·24	6·06	31·3	25·0	34·0	33·6
Dodge City, Kansas	6·28	8·91	3·13	1·49	63·7	49·5	62·0	65·7
Cape Mendocino, Cal	6·25	0·02	5·05	8·02	29·3	28·7	33·2	30·7

TABLE VI (*continued*).

	Average precipitation. Inches of rain and melted snow, computed from commencement of observations to January 1, 1884. (5)				*Means of extreme monthly ranges of temperature, from commencement of observations to January* 1, 1884. (8)			
	Spring.	Summer.	Autumn.	Winter.	Spring.	Summer.	Autumn.	Winter.
FIRST HALF MODERATE MOISTURE.								
Lynchburg, Virginia........	10·3	10·8	9·9	9·7	50·1	36·9	46·0	51·5
Yankton, Dakota...........	9·0	12·1	5·1	2·1	63·9	46·8	63·4	68·2
Leavenworth, Kansas.......	11·0	13·9	9·0	4·8	56·2	40·8	54·8	61·3
Savannah, Georgia..........	11·9	19·3	11·7	10·1	40·2	28·8	38·2	45·2
San Francisco, California....	5·4	0·2	4·0	14·1	28·3	25·1	27·6	22·4
SECOND HALF MODERATE MOISTURE.								
Atlanta, Georgia	15·5	10·6	11·0	19·8	44·9	33·1	41·9	48·5
St. Paul, Minnesota	7·4	12·2	6·9	3·4	55·8	43·4	54·3	59·3
Jacksonville, Florida	10·5	17·8	15·4	9·8	41·8	29·2	37·3	44·9
Washington, D. C..........	10·1	13·3	10·3	8.9	51·9	39·7	44·3	55·0
Boston, Massachusetts......	12·5	11·8	12·7	11·1	51·1	42·9	48·5	55·7
FIRST HALF EXTREME MOISTURE.								
Buffalo, New York	8·3	9·5	10·7	8·5	48·6	36·3	45·1	48·5
Milwaukee, Wisconsin	9·6	10·3	8·2	5·7	48·9	50·8	49·3	55·9
Atlantic City, New Jersey...	9·9	11·5	10·0	10·7	45·5	34·4	43·8	48·7
Nashville, Tennessee	14·5	12·6	10·5	14·1	48·5	35·7	47·9	53·7
Galveston, Texas	10·2	13·5	17·1	11·6	30·8	21·5	33·3	36·8
SECOND HALF EXTREME MOISTURE.								
St. Louis, Missouri	10·3	11·7	8·1	7·5	51·9	37·5	50·8	59·3
Grand Haven, Michigan	8·7	10·9	11·1	6·6	49·2	38·0	41·6	45·9
Erie, Pennsylvania..........	9·3	10·5	13·1	9·8	52·6	36·8	44·2	51·2
Indianola, Texas	7·4	9·3	13·2	7·5	37·8	25·8	37·0	44·3
Delaware Breakwater, Del. ..	6·6	9·0	7·9	9·0	41·1	29·4	37·8	42·9
FIVE GREATEST MOISTURE.								
Brownsville, Texas	4·7	9·7	11·2	6·4	40·7	26·2	38·7	45·7
Hatteras, North Carolina....	18·1	17·5	20·8	18·3	35·7	27·3	35·5	41·4
Charleston, South Carolina ..	14·2	19·7	14·9	11·1	40·2	28·9	37·3	43·3
Fort Macon, North Carolina..	15·1	20·1	15·1	14·6	36·8	25·3	36·7	40·7
Port Huron, Michigan	9·5	10·0	8·3	6·8	53·3	41·6	48·7	50·4

The places of extreme dryness, according to the rating rule, are more than twice as variable in daily temperature than those of extreme moisture, while the monthly means regularly decrease in variability at

the rate of about 4° for each division of climate from the extreme of dryness to the extreme of moisture.*

Physical Effects of Dryness.

There are so many conditions which on the one hand vary the character of the air breathed, and on the other the respiratory activity, that any opinion of the effect of dryness which we can formulate will be only approximate. The chief effect, of course, is upon pulmonary transpiration, and enough can be gleaned from the experiments of Valentin, Sanctorius, Lavoisier, Seguin, Dalton, and others, to understand that this process is a very important part of our physiology; yet all of these investigators miss the mark we are now aiming at, which is to determine the amount of moisture exhaled (above that inhaled) in a dry *more* than in a damp atmosphere. They may all agree with Valentin that the amount exhaled in each twenty-four hours varies from 6,000 to 12,000 grains of vapor, according to the respiratory capacity, etc., in a man not severely exercising. I have not, however, been able to find any comparisons based upon the hygrometric condition of the air breathed.

Temperature and altitude, with distance from the sea, are such powerful agents in producing dryness that it is well for us to divide our own inquiry—namely, the increased pulmonary transpiration in (1) warm dry, and (2) in cold dry air.

First in warm dry as compared with warm moist air. Let us choose Yuma, Arizona, and Jacksonville, Fla., for the autumn of 1883, as they both had the same mean temperature for that season—71·3. Dalton assumes, in his calculations, that the air passes from the lungs in a state of saturation, and Draper puts the dew-point of expired air at 94°. Let us assume that the expired breath brought down to 94° is saturated with vapor; that an ordinary-sized man breathes eighteen times a minute (Quetelet) and expires twenty cubic inches at each breath when at rest (Hutchinson, Flint Jr., and others); that he breathes the same amount of air in Jacksonville as in Yuma, and that the loss by breathing of $\frac{1}{70}$ to $\frac{1}{50}$ in volume (Davy and Cuvier) is made up by the expansion of the air in the lungs being raised from 71·3° to the heat of the body. We have, then, the following calculation:

* In making these computations, one can not help noticing the equalizing influence of the summer temperatures, an effect increasingly apparent as the extreme of moisture is approached. This is in perfect harmony with the preference to be given to a cool or cold temperature when desirable dryness is to be sought for a given invalid.

AUTUMN, 1883.	YUMA.	JACKSONVILLE.
Mean temperature	71·3°	71·3°
Weight of vapor with air saturated (Glaisher)	8·33 grains.	8·33 grains.
Mean relative humidity	·428	·774
Air breathed in 24 hours	300 cubic feet.	300 cubic feet.
Vapor inhaled in 24 hours	1,070 grains.	1,934 grains.
Vapor exhaled in 24 hours, with dew-point at 94°	5,007 grains.	5,007 grains.
Vapor exhaled more than inhaled in 24 hours	3,937 grains.	3,073 grains.

Excess for Yuma over Jacksonville, 864 grains a day.

The amount of air breathed ought to be increased one fifth, on account of the increase of breathing due to ordinary exercise. We thus have about 2½ ounces, or ⅔ of a gill, more moisture exhaled in Yuma than in Jacksonville each day.

Crawford has shown by experiments that the exhalation of carbonic acid from the lungs is much greater in low than in high temperatures, and Draper says twice as much carbonic acid is liberated with a temperature of 68° as at 106°, while Lehmann * has likewise shown that exhalation of carbonic acid is greater in a moist than a dry atmosphere, temperature remaining the same.† Therefore we are compelled, in order to favor the exhalation of carbonic acid, to take our dryness with the favorable cold temperature. This leads us to the more important comparison—that between warm moist and cold dry air. It is here that altitude, distance from the sea, etc., come in, as they produce both the coldness and the dryness we need.‡

Let us choose Denver and Jacksonville for the autumn of 1883, and give Denver the benefit of one fifth greater amount of air breathed, the air there being about one fifth rarefied. This will account for the deeper and more frequent respirations # and the corresponding greater activity of the heart in ordinary life, but not for the greater increase under severe exercise, like climbing hills, etc.

* Lehmann, "Physiological Chemistry," Philadelphia, 1855, vol. ii, p. 414.

† Dr. Lombard, of Geneva, in a paper presented to the International Congress of Hygiene (September, 1882), concludes that "in the altitudes the digestion, the muscular exercise, and the lowering of the temperature increase and accelerate the exhalation of carbonic acid."

‡ I have in mind the excellent results obtained in a year's sojourn in Colorado by a patient of mine, the daughter of a London physician, who had wintered in Algiers, a very warm dry place, and spent two winters at Davos, Switzerland, but is now decidedly confirmed in favor of Colorado as a sanitarium. The experience of other patients, who tried southern California and then settled in Colorado, also strengthens this preference to be given to dryness with a cool temperature.

This allowance is equal to three respirations and three to five more cubic inches of air inhaled each minute.

We will assume as breathing in both places a good-sized man, thirty years old, breathing eighteen times a minute at sea-level, and expiring an average of thirty cubic inches (Dr. Gréhaut), ordinary exercise included:

AUTUMN, 1883.	DENVER.	JACKSONVILLE.
Mean temperature	50·4°	71·3°
Weight at saturation for given temperature grains in a cubic foot	4·44	8·33
Mean relative humidity	·501	·774
Amount of air breathed in 24 hours	933,120 cub. in., or 540 cub. ft.	777,600 cub. in., or 450 cub. ft.
Vapor inhaled in 24 hours	1,461 grains.	2,901 grains.
Vapor exhaled in 24 hours at 94° dew-point	9,013 grains.	7,510 grains.
Vapor exhaled above that inhaled in 24 hours	7,552 grains.	4,599 grains.

Denver's excess in transpiration, 2,453 grains, or $5\frac{3}{8}$ ounces, or $1\frac{2}{3}$ gills.

This would amount to over six ounces, or one and a half gill, if the considerable expansion of the air in being raised in the lungs from 50° to 98° is accounted for at Denver.

Denver and Cedar Keys, compared in the same way for last winter, results in 2,935 grains, or $1\frac{2}{3}$ gill more moisture being exhaled from the lungs in Denver than in Cedar Keys. Now, I wish to ask, Does it not stand to reason that this transpiration of surplus vapor is a most admirable vehicle for carrying away effete matter, wasted tissue, and the germs of disease (bacilli)? Is it a wonder that thirst for fluids, an appetite for food, as well as the ability to digest it, are greatly increased in all those who, coming to the elevated interior of our continent, can stand the strain without disturbance of the nervous system?

If the foregoing conclusions are reasonable, can you not imagine the decided influence, especially upon the respiratory activity and function, caused by climbing the hills and mountain-sides in Colorado, when one at sea-level, walking at the rate of three miles an hour, consumes three times as much air as when at rest (Dr. Edward Smith)?*

In fine, do you not think there was good ground for Dr. John Parkin's statement in the preface to the second edition of his brochure on "Climate and Phthisis"?†

* The uniformly increased thoracic capacity observed in young persons after taking up a residence in elevated regions, even to the production of local or general emphysema in some invalids who have had phthisis arrested there (Dr. C. Theo. Williams, London), is likewise explained by these considerations.

† Longmans, Green & Co., 1882.

"As so much ignorance exists in England on the subject of climate, even with medical men, and as so many invalids are annually subjected to what one writer has termed medical *transportation*, I am induced to publish another edition of this work in order to warn, once more, consumptive patients and others of the dangers attendant upon a sojourn in the south of Europe, and other warm climates more especially."

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